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Health and Human Services Joint Appropriation Subcommittee, 62nd Legislature

to

Department of Public Health and Human Services

concerning

Electronic Health Records information

January 31, 2011

MONTANA
Department of Public Health & Human Services

DEPARTMENT OF
PUBLIC HEALTH AND HUMAN SERVICES

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GOVERNOR

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January 28, 2011

Representative Don Roberts, Chair
Appropriations Subcommittee
Health and Human Services
State Capitol Building
Helena, MT 59620

Dear Chairman Roberts:

In response to recent Subcommittee discussion concerning the use of electronic health records (EHR), I wanted to provide additional information on this issue.

The use of electronic medical records and clinical decision support systems is still very much in its infancy. As with the implementation of many new technologies, the long term benefits require the availability of adequate evidence and experience so that comprehensive studies using quantitative data can be performed and validated. Such studies require the ability to reasonably compare systems of similar functionality and benefits with a common basis for comparison. Studies use different data sources, metrics, and research methods. And, consequently, such studies show much variation.

But, the fundamental question facing the Subcommittee is not the short or long term value of EHR technology, but whether it is important for Montana healthcare providers to possess the adequate information technology infrastructure required for the future. Several things are currently true:

1. The Centers for Medicare and Medicaid Services (CMS) is distributing nearly $20 million in American Recovery and Reinvestment Act (ARRA) funding to eligible healthcare providers for the purpose of EHR development and use.

2. If Montana providers do not have access to this funding, the money will go to providers in other states. Three states, Oklahoma, Kentucky and Louisiana, are currently processing registrations and making incentive payments to providers. The University of Kentucky's UK HealthCare Hospital received an initial payment of $2.8 million on Jan 5, 2011. Per CMS, at least 23 more states plan to launch their programs in 2011. Large Medicaid states with thousands of eligible providers, such as California, are currently in the implementation phase.

3. Providers (hospitals and physicians) face penalties from Medicare in the form of lower claim payments if they do not eventually update electronic health record capabilities. A survey just

completed by HealthShare Montana indicated cost of information technology as the primary barrier to the use of electronic health records among Montana providers.

4. Montana's healthcare providers must have the technology to access and share patient data, gain operational efficiencies, and compete for the best and brightest employees to staff their practices and facilities. The inevitable outcome of these achievements will be an improved ability to care for Montana's citizens.

Montana providers, and certainly Montana's Critical Access Hospitals, would benefit from this opportunity to upgrade their health information technology functionality. The incentive funding available through CMS will provide much needed capital for Montana providers to adopt, implement, and use technology that will be required of every healthcare provider in the very near future.

In this binder, I have included additional information detailing the benefits of EHR as well as several attachments of surveys, studies, and case stories that outline some of the positive aspects of the adoption and use of meaningful EHR.

Sincerely,

Anna Whiting Sorrell, Director

Benefits of Electronic Health Records

Increased Efficiency - Initially there is almost always a hit to the efficiency of a practice during an EHR implementation. However, many practices will find that after the initial slow down, they are able to see more patients and document treatment in less time than they did before an EHR.

Better Patient Services – While it may take time for providers to implement some of the more patient centric functionality related to most EHR systems, creating the HIT infrastructure that allows patient related services like online appointment scheduling or online prescription refills can improve the patient's overall satisfaction with their treatment and care.

Improved Workflow - Many practices have reported improved clinical workflow after implementing an EHR. Part of this relates to the workflow evaluation that is often done while implementing an EHR. The other part is that an EHR can improve on the manual paper workflows of the past.

- **Accessibility of Charts** - Patients charts are automatically indexed and easily searchable by multiple identifiers. No more searching the entire clinic for the paper chart in medical records since it can be pulled up from computer or other mobile devices connected to EHR system.

- **No More Lost Charts** - No more wondering if the paper chart was left in the doctor's office, in the exam room, at the nurses' station, in the lab sign off box, etc. Time spent looking for charts is eliminated.

- **Multiple Users Accessing Chart** - Most EHR programs support multiple users accessing a chart at the same time. Many even allow multiple people to chart notes at the same time also.

- **No Time Spent Pulling and Filing Charts** - All the charts are available and easily accessible. No one has to pulling and refiling.

Electronic Prescriptions - Scripts sent electronically or printed out avoid problems of legibility by the pharmacy receiving the script, thus less likelihood of error versus written scripts. Pharmacies will need to call less since they will not have issues reading the scripts created electronically or printed out.

Drug to Drug and Allergy Interactions - Can provide a point of reference for doctor to evaluate the medications prescribed based on factors that may have been missed or forgotten. In complex cases where a patient is on multiple drugs with multiple allergies this is even more valuable.

Disaster Recovery – Data can be stored in multiple locations and across multiple time periods for better disaster recovery. In an emergency, entire patient database could be portable. You can't carry a room full of paper charts with you in an emergency.

Automated Lab Results - This depends on a lab interface, but is more reliable and integrated with the care given. In a two way lab interface the order is made in an EHR system and is sent automatically to the lab performing the test. Once the test results are processed by the lab, the results are sent back to the EHR automatically. In a one way lab interface, the order is made through paper or some other process, but the results are sent back electronically to the EHR.

Automated X-ray Results - This also depends on a X-ray interface, but has the same possible benefits of a lab interface. In a two way X-ray interface the order is made in an EHR system and is sent automatically to the radiology software. Once the X-ray results are processed by the radiologist, the results are sent back to the EHR automatically. In a one way X-ray interface, the order is made through paper or some other process, but the results are sent back electronically to the EHR.

Clinical Decision Support - Many EHR software vendors are integrating decision support into their software to help clinicians make better decisions. Most allow the clinic to customize the clinical decision support to meet the guidelines of that practice. Often the impact of this isn't seen immediately after implementing an EHR, but is a longer term benefit of implementing an EHR.

Improved Patient Communications - Most EHR software has a number of electronic options for communicating with the patient. Patient education materials, appointment reminders, follow up appointments, care management messages, and other patient communication can often be automated using an EHR. Many EHR systems support email, SMS text messages, and phone calls.

Interoperability – In Montana, we have regional, statewide, and national initiatives supporting interoperability of healthcare data. Also, vendors like Google Health and Microsoft HealthVault are also creating a new demand from consumers for healthcare data to be interoperable.

Transcription Costs Savings - Many users have been able to save on transcription costs by implementing an EHR. Often the transcription costs are replaced by point and click template systems or through the use of some sort of voice recognition software.

Office Efficiency – Includes space savings (smaller offices with less storage or creating more space for revenue generating activities). Includes paper savings (won't eliminate use of paper, but there will be significant reduction in paper related costs of paper filing systems, i.e. files, cabinets, supplies, etc). Includes potential staff savings.

Pay-for-performance Eligibility - It is likely that doctors will be subject to some type of new pay for performance initiatives as part of reimbursement practices in the future. Without an EHR, it will be difficult or impossible to qualify for these incentives. An EHR can also make it easier for a doctor interested in the PQRI incentives.

Order Sets - Order sets provide a standard of care that can be used to ensure thorough treatment of patients. This is especially good when new doctors are brought into a practice. Order sets can also streamline the order entry process.

Reporting - standard reports to track every facet of patient interaction, unlimited access to the data for reporting purposes.

Attachments

It is easy to get lost in the volumes of scholarly publications related to health information technology and electronic medical records. Some, including a recently published study by Dr. Randall Stafford of Stanford University, point to the lack of "evidence linking increased national use of outpatient EHRs to improved quality". While others, point to empirical and intrinsic evidence of not only improved clinical outcomes, but will help greatly in controlling duplicative radiology and laboratory testing. In addition, large scale providers such as Kaiser Permanente are encouraged by increased staff efficiencies, declines in unnecessary office visits, and increased use of telephone, secure e-mail services, and other non-traditional patient centered treatment.

The surveys, studies, and case stories cited below outline some of the positive aspects of the adoption and use of meaningful electronic medical records and clinical decision support systems:

A. Electronic Medical Record/Electronic Health Record Systems of Office-based Physicians: United States, 2009 and Preliminary 2010 State Estimates (Centers for Disease Control and Prevention's National Center for Health Statistics)

   This survey explores the number of office based physicians with access EHR systems.

B. Return On Investment: The Case for EHR Adoption in the Physician Practice

   Diagram developed by the Oklahoma Foundation for Medical Quality which illustrates both measurable and intrinsic savings associated with the implementation of electronic health record technology.

C. The Value of Electronic Health Records in Solo or Small Group Practices

   Case studies of fourteen solo or small-group primary care practices using electronic health record (EHR) software from two vendors. Initial EHR costs averaged $44,000 per full-time-equivalent (FTE) provider, and ongoing costs averaged $8,500 per provider per year. The average practice paid for its EHR costs in 2.5 years and profited handsomely after that; however, some practices could not cover costs quickly, most providers spent more time at work initially, and some practices experienced substantial financial risks.

   The study's conclusion is that policies should be designed to provide incentives and support services to help practices improve the quality of their care by using EHRs. The Medicaid and Medicare Provider Incentive Programs are the direct result of widespread agreement of findings such as these.

D. The Value of Electronic Health Records in Community Health Centers

   This paper analyzes the costs and benefits of electronic health records (EHRs) in six community health centers (CHCs) that serve disadvantaged patients. EHR-related benefits for most study CHCs did not pay for ongoing EHR costs, yet quality improvement (QI) was substantial.

E. Electronic Health Records in Ambulatory Care – A National Survey of Physicians

National survey of 2758 physicians, with a response rate of 62%. The results of the survey showed four percent of physicians reported having an extensive, fully functional electronic records system, and 13% reported having a basic system. In multivariate analyses, primary care physicians and those practicing in large groups, in hospitals or medical centers, and in the western region of the United States were more likely to use electronic health records.

Physicians reported positive effects of these systems on several dimensions of quality of care and high levels of satisfaction. Financial barriers were viewed as having the greatest effect on decisions about the adoption of electronic health records. The final conclusion of the survey is that physicians who use electronic health records believe such systems improve the quality of care and are generally satisfied with the systems.

F. Electronic Health Records: Improving Patient Safety and Quality of Care in Texas Acute Care Hospitals

Study conducted of 253 acute care hospitals in Texas using 11 mortality indicators showed that the use of EHRs has the potential to decrease mortality rates while significantly improving patient safety.

G. Impact of Electronic Health Record Clinical Decision Support on Diabetes Care: A Randomized Trial

Physicians in this study used an EHR-based decision support system at 62.6% of all office visits made by adults with diabetes. The intervention group diabetes patients had significantly better hemoglobin A1c, and better maintenance of systolic blood pressure control and borderline better maintenance of diastolic blood pressure control, but not improved low-density lipoprotein cholesterol levels than patients of physicians randomized to the control arm of the study. Among intervention group physicians, 94% were satisfied or very satisfied with the intervention.

The study concluded that EHR-based diabetes clinical decision support significantly improved glucose control and some aspects of blood pressure control in adults with type 2 diabetes.

H. Effectiveness of Clinical Decision Support in Controlling Inappropriate Imaging

This study showed that the use of imaging clinical decision support was associated with substantial decreases in the utilization rate of lumbar MRI for low back pain, head MRI for headache, and sinus CT for sinusitis. There was a corresponding significant decrease in overall imaging volumes (all diagnoses) for lumbar MRI, head MRI, and sinus CT, with no observed effect for the head CT control group.

The study concluded that targeted use of imaging clinical decision support is associated with large decreases in the inappropriate utilization of advanced imaging tests.

I. Case Study: Kaiser Permanente Electronic Health Record

This case study examined the impact of implementing a comprehensive electronic health record (EHR) system on ambulatory care use in an integrated health care delivery system with more than 225,000 members.

Between 2004 and 2007, the annual age/sex-adjusted total office visit rate decreased 26.2 percent, the adjusted primary care office visit rate decreased 25.3 percent, and the adjusted specialty care office visit rate decreased 21.5 percent. Scheduled telephone visits increased more than eightfold, and secure e-mail messaging, which began in late 2005, increased nearly sixfold by 2007.

Introducing an EHR creates operational efficiencies by offering nontraditional, patient-centered ways of providing care.

J. Case Study: Cherokee Indian Hospital

An outline of the EHR experience of the Cherokee Indian Hospital in Cherokee, NC. This provider experienced improved clinical outcome measures such as desired levels of blood pressure and LDL-cholesterol – two key bellwethers of cardiovascular disease. The hospital continued to report sustained improvements even after increases in patient population and hospital staff turnover. However prior to the system's implementation, CIH's clinical staff could not have predicted the increased openness of physician to patient communications that their new EHR system would afford them. The system generates a patient wellness handout and a diabetes care summary that encourages conversation and reminds both providers and patients of standards of care. In many cases, the clinicians found improved screening was itself therapeutic as patients became more aware of their own conditions.

K. Case Study: Finding My Way to Electronic Health Records by Regina Benjamin, M.D., M.B.A – Surgeon General of the United States

This article reflects on the personal experience of the U.S. Surgeon General in the aftermath of devastating hurricanes and a fire that hit her clinic in the small town of Bayou La Batre, LA.

December 2010

Electronic Medical Record/Electronic Health Record Systems of Office-based Physicians: United States, 2009 and Preliminary 2010 State Estimates

by Chun-Ju Hsiao, Ph.D.; Esther Hing, M.P.H.; Thomas C. Socey; and Bill Cai, M.A.Sci., Division of Health Care Statistics

Policymakers' interest in the progress of health information technology adoption by health care providers has increased greatly since The American Recovery and Reinvestment Act was signed into law in 2009. A portion of the bill, the Health Information Technology for Economic and Clinical Health Act, authorized incentive payments through Medicare and Medicaid to providers that use certified electronic health records to achieve specified improvements in care delivery (1). The U.S. Department of Health and Human Services finalized the meaningful use criteria for the first 2 years of the three-stage incentive program in mid-2010 (2).

The National Ambulatory Medical Care Survey (NAMCS), conducted by the Centers for Disease Control and Prevention's National Center for Health Statistics (NCHS), is an annual nationally representative survey of patient visits that includes office-based physicians and collects information on the adoption and use of electronic medical records/electronic health records (EMRs/EHRs). Since 2008, a supplemental mail survey on EMRs/EHRs has been conducted in addition to the core NAMCS, an in-person survey. In 2010, the mail survey sample size increased five-fold to allow for state-level estimates, and survey questions were slightly modified to ask physicians about their intentions to apply for meaningful use incentive payments.

EMR/EHR systems of office-based physicians—The estimate of all or partial EMR/EHR systems was obtained from the question, "Does this practice use electronic medical records or electronic health records (not including billing records)?" In addition to the question asking about all or partial EMR/EHR systems, physicians also reported the computerized functionalities of their practices. EMR/EHR systems were classified as basic or fully functional (see Table) (3).

There has been an increasing trend in EMR/EHR use among office-based physicians from 2001 through the preliminary 2010 estimates (Figure 1). Combined data from the 2009 surveys (mail survey and in-person survey) showed that 48.3% of physicians reported using all or partial EMR/EHR systems in their office-based practices. About 21.8% of physicians reported having systems that met the criteria of a basic system, and about 6.9% reported having systems that met the criteria of a fully functional system, a subset of a basic system. Preliminary 2010 estimates from the mail survey showed that 50.7% of physicians reported using all or partial EMR/EHR systems, similar to the 2009 estimate. About 24.9% reported having systems that met the criteria of a basic system, and 10.1% reported having systems that met the criteria of a fully functional system, a subset of a basic system. Between 2009 and 2010, the percentage of physicians reporting having systems that met the criteria of a basic or a fully functional system increased by 14.2% and 46.4%, respectively. Due to questionnaire modifications in 2010, survey items used to define basic and fully functional systems are slightly different from 2009 (see Table).

Preliminary 2010 estimates from the mail survey showed that the percentage of physicians using all or partial EMR/EHR systems by state ranged from 38.1% to 80.2% (Figure 2). The percentage of physicians having systems that met the criteria of a basic system by state ranged from 12.5% to 51.5% (Figure 3). Excluding 27 states with unreliable estimates, the percentage of physicians having systems that met the criteria of a fully functional system across the United States ranged from 9.7% to 27.2% (data not shown).

Methods—NAMCS includes a national probability sample survey of nonfederal office-based physicians. The target universe of NAMCS physicians is physicians classified as providing direct patient care in office-based practices, including additional clinicians in community health centers. Radiologists, anesthesiologists, and pathologists are excluded. In 2008 and 2009, samples of physicians in the core in-person NAMCS and the supplemental mail survey stratified by specialty were selected from 112 geographic areas. To provide state-level estimates, the 2010 mail survey sample was selected from the 50 states and the District of Columbia.

In 2009, samples of 3,200 and 2,000 physicians were selected for the core in-person NAMCS and the supplemental mail survey, respectively. The 2009 core NAMCS covered from December 2008 through December 2009, and the 2009 mail survey March through June 2009. The final estimates of 2009 EMR/EHR use combine the core NAMCS and the mail survey. The unweighted response rate of the 2009 combined surveys was 70% (both unweighted and weighted).

From April through July 2010, NCHS surveyed a sample of 10,301 physicians with the mail survey and followed up with telephone calls to nonrespondents. The preliminary 2010 estimates reported here were based on the 2010 mail survey. The unweighted response rate was 68% (66% weighted) in 2010. A copy of the 2009 and 2010 surveys can be obtained from the NCHS website: http://www.cdc.gov/nchs/ahcd/ahcd_survey_instruments.htm#namcs.

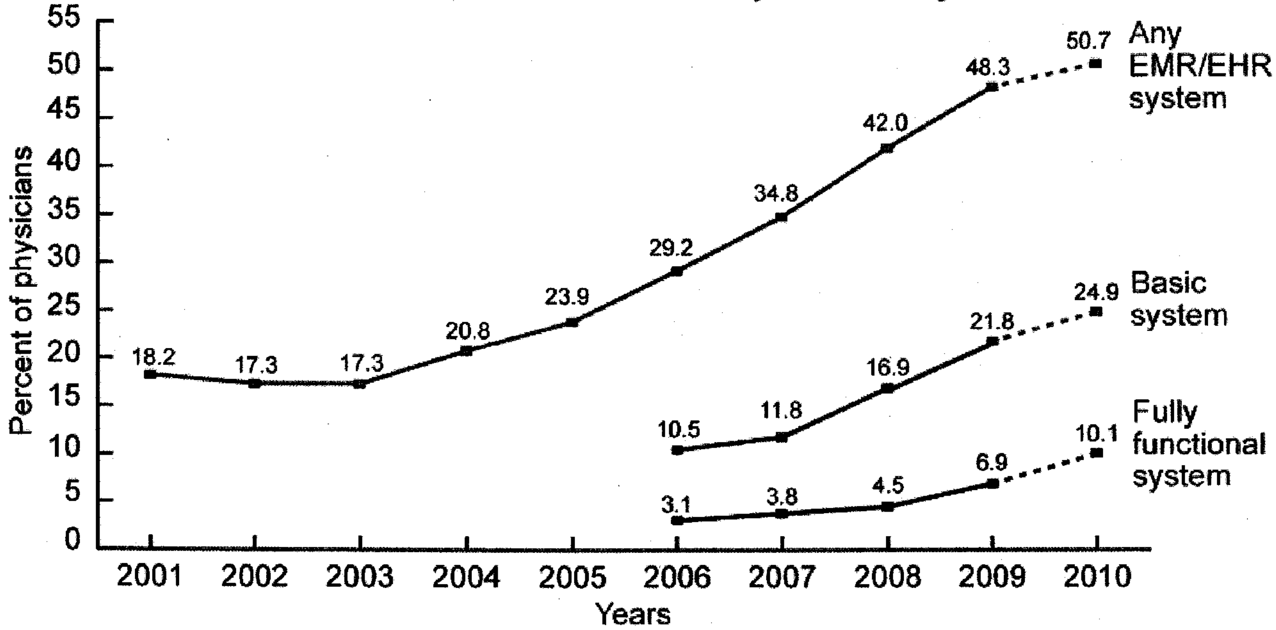
Statements of differences in estimates are based on statistical tests with significance at the $p<0.05$ level. Terms relating to differences, such as "increased" or "decreased," indicate that the differences are statistically significant. A lack of comment regarding the difference does not mean that the difference was tested and found to be not significant.

References

1. Centers for Medicare & Medicaid Services. The official web-site forfor the Medicare and Medicaid EHR Incentive Programs. Available from: http://www.cms.gov/EHRIncentivePrograms/01_Overview.asp#TopOfPage.
2. Medicare and Medicaid EHR Incentive Program, 42 C.F.R. pts 412, 413, 422, and 495 (2010).
3. Health information technology in the United States: Where we stand, 2008. Robert Wood Johnson Foundation. 2008.
4. Hsiao CJ, Beatty PC, Hing E, Woodwell DA, Rechtsteiner EA, Sisk JE. Electronic medical record/electronic health record use by office-based physicians: United States, 2008 and preliminary 2009. National Center for Health Statistics Health E-stat. December 2009.

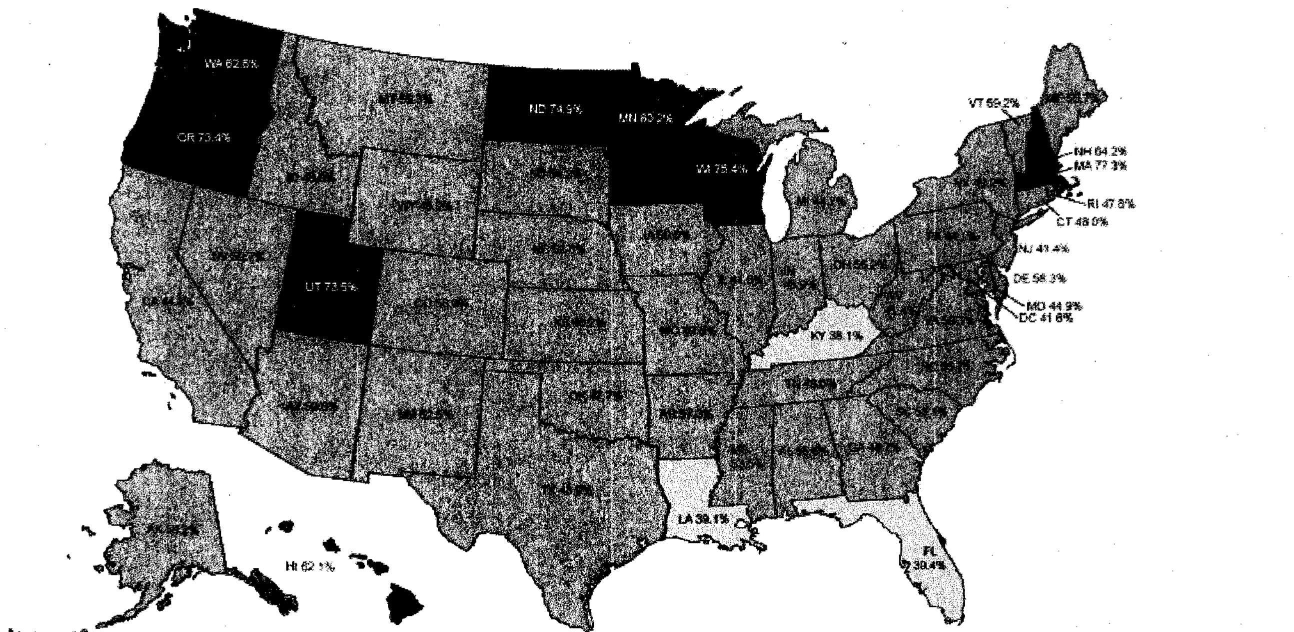
Figures

Figure 1. Percentage of office-based physicians with electronic medical records/electronic health records (EMRs/EHRs): United States, 2001–2009 and preliminary 2010



NOTES: Any EMR/EHR is a medical or health record system that is either all or partially electronic (excluding systems solely for billing). The 2010 data are preliminary estimates (as shown by dashed lines), based only on the mail survey. Estimates through 2009 include additional physicians sampled from community health centers; prior 2008 combined estimates were revised to include those physicians (4). Estimates of basic and fully functional systems prior to 2006 could not be computed because some items were not collected in the survey. Fully functional systems are a subset of basic systems. Some of the increase in fully functional systems between 2009 and 2010 may be related to a change in survey instruments and definitions of fully functional systems between 2009 and 2010 (see Table for more details). Includes nonfederal, office-based physicians. Excludes radiologists, anesthesiologists, and pathologists.
SOURCE: CDC/NCHS, National Ambulatory Medical Care Survey.

Figure 2. Percentage of office-based physicians using any electronic medical record/electronic health record (EMR/EHR) system, by state: United States, preliminary 2010

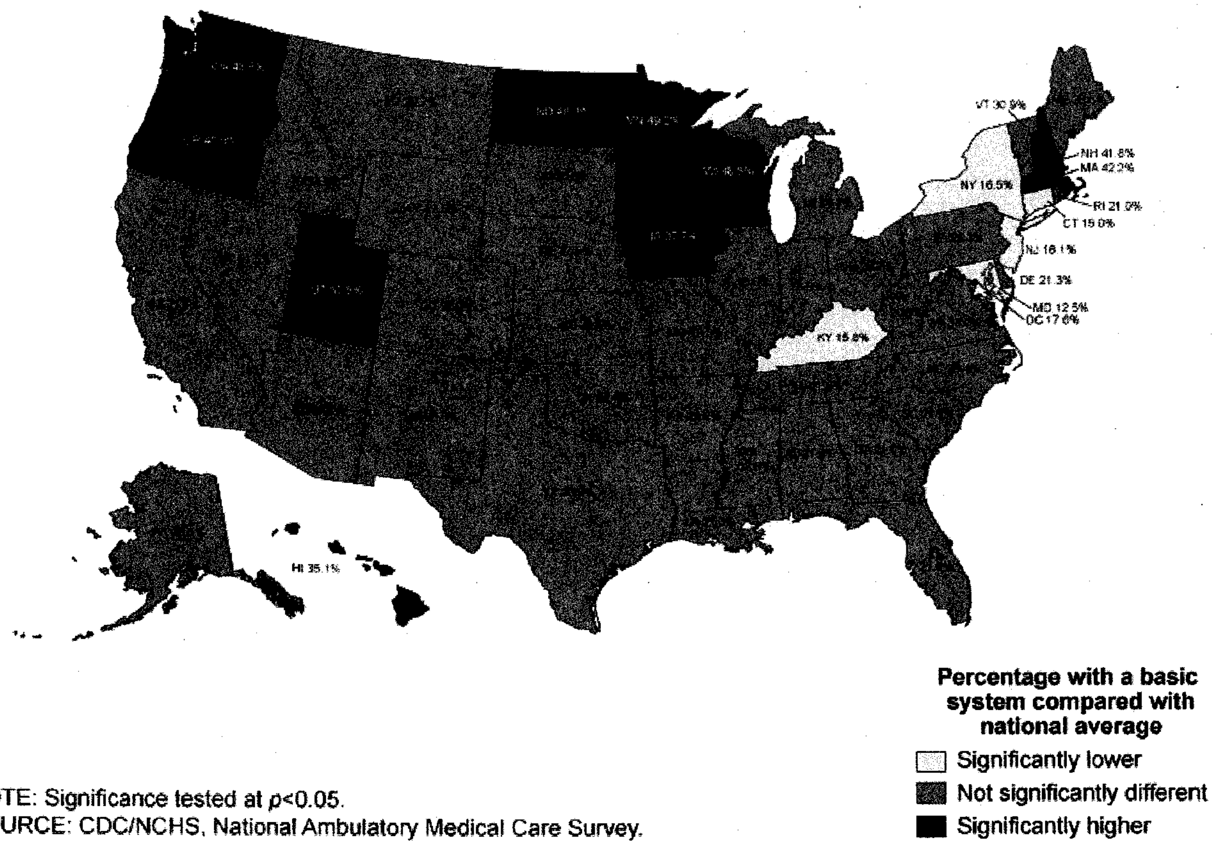


Percentage using any EMR/ EHR system compared with national average

- Significantly lower
- Not significantly different
- Significantly higher

NOTE: Significance tested at $p<0.05$.
SOURCE: CDC/NCHS, National Ambulatory Medical Care Survey.

Figure 3. Percentage of office-based physicians with a basic system, by state: United States, preliminary 2010



NOTE: Significance tested at p<0.05.
SOURCE: CDC/NCHS, National Ambulatory Medical Care Survey.

Table

Table. Survey items defining fully functional and basic electronic medical record systems

Feature of electronic medical record systems	Basic system[1]	Fully functional system[1]
Patient history and demographics	√	√
Patient problem lists	√	√
Physician clinical notes	√	√
Medical history and follow-up notes[2]	. . .	√
List of medications taken by patients[3]	√	√
Comprehensive list of the patient's allergies	. . .	. . .
Computerized orders for prescriptions	√	√
Drug interaction or contraindication warning provided	. . .	√
Prescription sent to pharmacy electronically	. . .	√
Computerized orders for lab tests	. . .	√
Test orders sent electronically	. . .	√
Viewing lab results	√	√
Results incoporated into EMR/EHR	. . .	. . .
Out-of-range values highlighted	. . .	√
Computerized orders for radiology tests[3]	. . .	√
Viewing imaging results	√	√
Electronic images returned[2]	. . .	√
Guideline-based interventions or screening tests	. . .	√
Electronic reporting to immunization registries	. . .	. . .
Public health reporting	. . .	. . .
Notifiable diseases sent electronically	. . .	. . .

. . . Category not applicable.

[1]Based on definition presented in *Health Information Technology in the United States: Where We Stand, 2008,* Robert Wood Johnson Foundation.

[2]Included in 2009, not available in 2010.

[3]Included in 2010, not available in 2009.

NOTE: Survey items are from the National Ambulatory Medical Care Survey.

ROI: The Case for EHR Adoption in the Physician Practice

Opportunities for Clear Cost Savings

Decrease Data Entry and Handling Costs

Benefit
- Improved efficiency when chart pulls and filing are eliminated

Eliminate Paper Charts and Costs

Benefit
- Eliminate paper charts
- Recapture storage areas

ROI
- Eliminate chart production costs, chart storage costs, chart maintenance costs

Increase Office Efficiency

Benefit
- Decrease access time for pulling charts
- Fewer lost charts

ROI
- Increased patient volume

Increase Staff Satisfaction

Benefit
- Decrease staff turnover

ROI
- Decrease costs associated with staff transitions, hiring, and training

Improve Clinical Care and Efficiency

Benefit
- Decrease patient history analysis time
- Decrease medication errors
- Improve decision support
- Optimize clinical response time
- Stronger adherence to clinical protocols
- Disease management
- Risk mitigation

ROI
- Increase patient volume

Enhance Revenue Improve Claims

Benefit
- Automate charge capture
- Improved E&M coding
- Accurate claim submission
- Improved re-submission

ROI
- Resolve undercoding and lost charges
- Fewer denied claims

This material was created by the Oklahoma Foundation for Medical Quality and adapted by Quality Insights of Pennsylvania, the Medicare Quality Improvement Organization for Pennsylvania, under contract with the Centers for Medicare & Medicaid Services (CMS). The views presented do not necessarily reflect those of CMS. Publication number 7SOW-PA-PHYS05.259.

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The Value Of Electronic Health Records In Solo Or Small Group Practices

Physicians' EHR adoption is slowed by a reimbursement system that rewards the volume of services more than it does their quality.

by Robert H. Miller, Christopher West, Tiffany Martin Brown, Ida Sim, and Chris Ganchoff

ABSTRACT: We conducted case studies of fourteen solo or small-group primary care practices using electronic health record (EHR) software from two vendors. Initial EHR costs averaged $44,000 per full-time-equivalent (FTE) provider, and ongoing costs averaged $8,500 per provider per year. The average practice paid for its EHR costs in 2.5 years and profited handsomely after that; however, some practices could not cover costs quickly, most providers spent more time at work initially, and some practices experienced substantial financial risks. Policies should be designed to provide incentives and support services to help practices improve the quality of their care by using EHRs.

ELECTRONIC HEALTH RECORDS (EHRs) have the potential to greatly improve quality, yet little is known about their costs and benefits in ambulatory care, especially in solo or small group practices, where more than two-thirds of U.S. physicians work.[1] These groups face some of the greatest challenges in successfully using EHRs, which in part explains their slow pace of health information technology (HIT) adoption.[2] Yet the literature on costs/benefits in solo and small group practices is scant, and policymakers have had to rely on estimates that are based on "expert opinion," rather than evidence.[3]

Our study objective was to determine the costs and benefits of EHRs in current "early-adopter" solo or small primary care group practices.[4] EHRs' financial costs and benefits can affect the rate at which providers adopt them, while quality improvement (QI) benefits can affect patients' health—which may then result in fi-

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nancial benefit to payers from avoiding "downstream" expenditures, especially for hospital and emergency room services.

Better cost and benefit data on EHRs in solo and small group practices can help policymakers formulate financial and nonfinancial incentives designed to achieve an acceptable rate of EHR adoption and higher levels of QI benefits at the lowest possible cost. How quickly physicians can recoup their investment in EHRs, and how much they can improve quality using EHRs, will help determine how, and how much, the Centers for Medicare and Medicaid Services (CMS) and health plans/employers need to pay for EHR adoption and use.

Study Data And Methods

■ **Case selection.** We conducted retrospective qualitative case studies of fourteen solo or small-group primary care practices in twelve states. We selected practices from customer lists provided by PMSI Inc. (vendor of Practice Partner) and A4 Health Systems, two leading vendors of EHR software in the solo/small-group market. We set the following extensive selection criteria to enable appropriate comparisons before and after EHR adoption: Selected primary care practices had used EHRs for one to three years when first contacted (enough time to get over disruption surrounding implementation), had full practices prior to implementation (which eliminated new practices), had relatively stable complements of billing providers, and could provide needed data. Approximately 20 percent of practices meeting these criteria agreed to participate (eight from one vendor and six from the other). Practices were compensated $1,400 (on average) for provider and staff time.

■ **Data.** We conducted semistructured interviews of self-identified EHR champions (physicians and office managers), observed providers' use of EHRs (in eleven practices), and reviewed vendor contracts and practice reports. The questionnaire was adapted from previous studies of EHRs that had already identified key themes and data.[5] We obtained data on practice operations, EHR-related hardware and software, selection and implementation processes, costs, financial benefits, use of EHR capabilities, QI efforts, and barriers and facilitators for achieving benefits.

Costs. We obtained data on one-time and ongoing EHR-related costs for hardware, software, information systems staffing and external contractor services, installation, training, abstraction, productivity loss, and telecommunications.[6]

Benefits. We also obtained data on efficiency savings (decreases in compensation for medical records and other support staff full-time-equivalent [FTE] positions and overtime, and decreases in transcription and paper supply costs), efficiency financial gains (increased visits due to reduced provider time per visit), and efficiency nonfinancial gains (decreased provider time at work). We also obtained data on revenue enhancement from higher payment for increased levels of coding for visits; EHRs enable more complete documentation of visit activities and more thorough visits, thus providing justification for higher coding. We calculated benefits to practices only, not to other stakeholders.[7]

We generated average costs and benefits per FTE billing provider for each practice and then averaged them across the fourteen practices without using weights. Data were more precise for financial costs than for benefits.[8]

■ **Quality improvement.** We examined QI activities for major chronic diseases/conditions (diabetes, asthma, coronary artery disease, and hypertension) and common prevention activities (immunizations, flu vaccinations, mammograms, and pap smears). We focused on key EHR-enabled QI activities that might lead to improved patient outcomes, including some in the Chronic Care Model.[9] We determined whether practices set specific QI performance targets, established care protocols, used templates (electronic forms) with or without coded data, provided flow sheets with longitudinal data (for example, tests and services), delivered reminders at the point of care, generated lists of patients needing services and followed up with those patients, created QI performance reports, provided patient self-management aids, or participated in QI collaboratives. We also examined external performance reporting and financial incentives to improve quality.

■ **Data collection, processing, and analysis.** We collected semistructured interview, contract, office report, and observational data from July 2004 through May 2005. We conducted initial interviews with EHR champions, summarized transcripts into Access databases and Excel spreadsheets, and then reinterviewed participants and followed up by phone and e-mail. In all, we conducted forty-five interviews, which took sixty hours; had numerous shorter communications; and conducted more than 200 hours of observation of forty billing providers.

Study Findings

■ **Practice characteristics.** The fourteen practices averaged 3.3 FTE billing providers, ranging from one to six FTEs. They averaged 2.5 FTE physicians and 0.8 FTE mid-level billing providers (mostly family and advanced nurse practitioners, or NPs); ten practices had at least one part-time NP or physician assistant (PA).

Practices had used their EHRs for more than two years (26.6 months) on average, ranging from fifteen to forty-five months. Eleven practices had tightly integrated their EHRs into their practice management systems, which handled practice billing and patient scheduling; demographic data flowed from this system to the EHR, and clinical data for billing flowed from the EHR to the management system. Three practices had no such data exchange.

■ **Use.** Virtually all providers used the EHR for most common tasks, including prescribing, documenting, viewing, and within-practice messaging, and almost all used it to assist in billing. Providers typically used templates (electronic forms) to document activities; they also used electronic forms to generate prescription and lab orders that were printed out for patients. Transcription was rare, and ten practices no longer routinely pulled paper charts. Few practices used the EHR for reporting (patient lists or provider performance), patient-provider communication, or communication from providers in the practice to those outside it.

■ **Financial costs.** Initial EHR costs were approximately $44,000 per FTE provider per year, and ongoing costs were about $8,500 per FTE provider per year (Exhibit 1). Initial costs for twelve of the practices ranged from $37,056 to $63,600 per FTE provider. Variations in financial costs reflect exceptional heterogeneity among small practices in pre-EHR hardware and in technical and negotiating skills.

Software, training, and installation costs averaged $22,038 per FTE provider. Where data permitted separate estimates, we calculated that software alone accounted for about one-third of overall costs. Software costs depended on such factors as interfaces, other EHR-related software, and the negotiating savvy of the EHR champion; one practice acquired sharply discounted software from another practice. Installation and training costs ranged from virtually none (where there were technically savvy EHR champions) to more than $14,000 per FTE provider.

Hardware costs per provider averaged almost $13,000 per FTE provider, ranging from under $7,500 for four practices that had new equipment pre-EHR or acquired used equipment to more than $23,000 for two practices that had little usable pre-EHR equipment, including networking.

Revenue losses from reduced visits during training and implementation averaged $7,473 per FTE provider, ranging from none (in two practices) to $20,000 per FTE provider in one practice. Losses depended in part on the extent to which providers worked longer hours initially instead of reducing patient visits.[10]

Estimated ongoing EHR costs averaged $8,412 per FTE provider per year, or 19.5 percent of initial costs. Three ongoing cost categories—vendor software maintenance and support fees, hardware replacement, and payments for information systems staff or external contractors—accounted for 91 percent of these costs.

EXHIBIT 1
Electronic Health Record (EHR) Financial Costs Per Full-Time-Equivalent (FTE) Provider, For Fourteen Solo/Small Group Practices, 2004–05

	Average per FTE provider[a] ($)	Percent of total	Median ($)	Minimum ($)	Maximum ($)
Initial costs	43,826	100.0	45,747	14,462	63,600
Software training, installation	22,038	50.3	22,834	8,475	32,607
Hardware	12,749	29.1	12,492	5,261	23,600
Lost revenues from reduced productivity	7,473	17.1	7,473	0	20,000
Other	1,145	2.6	0	0	9,652
Ongoing costs per provider per year	8,412	100.0	7,231	5,957	11,867
Software maintenance and support	2,439	29.0	2,403	1,200	3,800
Hardware replacement	3,187	37.9	–[b]	–[b]	–[b]
Internal IS staffing/external IS contractors	2,047	24.3	683	0	5,556
Other	739	8.8	586	0	2,742

SOURCE: Authors' study data.
NOTE: IS is information systems.
[a] Average costs per provider were calculated for each practice and then averaged across the fourteen practices.
[b] Average annual hardware replacement costs per provider were estimated for all practices, not by practice.

Financial benefits. Financial benefits averaged approximately $33,000 per FTE provider per year (Exhibit 2). Providers obtained financial benefits from two main sources: increased coding levels, and efficiency-related savings or revenue gains. Increased coding levels accounted for more than half of financial benefits, or $16,929 per FTE provider per year, ranging from $3,040 to $41,711 in the ten practices with coding-related gains. Efficiency-related savings and revenue gains combined accounted for 48.3 percent of financial benefits, or $15,808 per FTE provider per year. Efficiency-related savings (40.1 percent of benefits) consisted mostly of a decrease in personnel costs. All practices reported some savings, ranging from $1,000 to $42,500 per FTE provider per year (for a practice with extensive medical record and transcription savings). Efficiency-related revenue gains from increased visits accounted for 8.1 percent of financial benefits, but only three practices reported gains.

Noticeably absent were substantial pay-for-performance rewards from health plans for QI. Two practices reported nominal quality performance rewards (one received under $400). One practice received an annual $300 per provider discount on malpractice insurance.

Time to pay back EHR costs. Assuming some lag time (say, six months) in generating benefits, the average practice paid for its initial and cumulative ongoing EHR costs within two and a half years and began to reap more than $23,000 in net benefits per FTE provider per year. The median practice took even less time to pay for EHR costs. However, practices varied in benefits and costs: Although ten of fourteen practices would pay for their EHR costs within four years, one practice would

EXHIBIT 2
Electronic Health Record (EHR) Financial Benefits Per Full-Time-Equivalent (FTE) Provider, For Fourteen Solo/Small Group Practices (Benefits Per Year), 2004–05

	Average per FTE provider[a] ($)	Percent of total benefits	No. of practices with benefits	Median ($)	Among practices with benefits: Minimum ($)	Maximum ($)
Total benefits per provider	32,737	100.0	14	38,450	6,600	56,161
Increased coding levels	16,929	51.7	10	21,250	3,040	41,711
Efficiency savings/gains	15,808	48.3	14	14,611	1,000	50,700
Efficiency savings	13,144	40.1	12	12,444	1,000	42,500
Personnel savings (excluding transcription)	6,759	20.6	9	8,333	5,333	30,000
Transaction savings	5,334	16.3	7	10,800	8,500	12,000
Paper supplies savings	1,051	3.2	9	1,000	500	5,333
Efficiency revenue gains from increased visits	2,664	8.1	3	8,200	6,600	22,500

SOURCE: Authors' study data.
[a] Average benefits per provider were calculated for each practice and then averaged across the fourteen practices.

take nine years, and two would never pay for their EHRs, assuming unchanged benefits. However, practices were optimistic about increasing benefits, including practices that were slow to realize financial benefits.

■ **Risk.** Three practices experienced considerable financial risks, other than a long payback period. Two had severe billing problems that were at least partly EHR-related. One had no billing or revenue for three months; another had no revenue for ten months (and nearly went bankrupt). A third had to redo its billing for the first six weeks after implementation and later endured a complete system crash that resulted in total loss of data and several weeks of providing care with no computer access or paper charts. Moreover, this survey did not include practices that had implemented an EHR and then returned to paper, thereby losing their total EHR investment.

■ **Time costs and benefits, and quality of life.** Interviewees reported that providers worked longer hours for an average of four months (ranging from one to twelve months), mostly because of the need to enter clinical data during the patient's initial visit after implementation and to become familiar with using the software. EHR physician champions had especially heavy time costs, as they made complementary process changes to improve efficiency and quality—for example, they altered exam room/office procedures, revised templates (forms) to capture needed data, and resolved or prevented some technical difficulties. Champions that focused on QI incurred even greater time costs, as discussed below.

Quality of life improved for some providers after the implementation period. Three practices that saw the same number of patients in less time took the gain as more personal time, rather than seeing more patients. Providers in most practices particularly liked accessing records from home, which enabled some of them to go home earlier, spend time with family, and then work later in the evening. They also liked being able to immediately access records when on call.

■ **QI activities.** EHR use confers some "automatic" presumed quality benefits, such as improved data organization, accessibility, and legibility. However, although all practices engaged in some specific EHR activities that should result in QI, only two extensively used their EHRs to improve chronic and preventive care.

Of the fourteen practices, only five had specific performance targets for QI, and only four had specific protocols/plans for delivering needed care. All but one practice regularly used templates to document encounters, but only seven had templates with substantial coded data that can enable more extensive reminders and reporting. Similarly, although twelve practices reported using some form of computerized reminders beyond drug-related alerts, only five had reminders, set by the practice, for at least one type of chronic care patient (rather than having physicians set reminders for specific patients). Only four practices created lists of at least some patients requiring needed services—for example, diabetics overdue for a glycosylated hemoglobin test—or had a routine way of following up with patients on lists for needing services. Finally, only two practices generated reports on provider performance—both belong to external QI collaboratives.

Discussion

A "typical" primary care physician in a solo or small group practice could generate the average gains in each financial benefit category by increasing coding levels for approximately 15 percent of visits, eliminating 0.25 of an FTE medical records staffer, eliminating transcription, and having 1 percent more patient visits. All of these benefit gains are plausible.

One recent peer-reviewed study estimated EHR financial costs and benefits to the practice.[11] Our cost estimates were about two-thirds higher; benefit estimates were similar, but the composition of costs and benefits differed greatly, as the other study obtained data from practices in a large integrated delivery network/ academic health center, which had robust information systems and management staffing, extensive pre-EHR hardware, lower-cost software, and some capitated patients. That study also relied partly on estimates from the literature and an expert panel. Compared with our past study on EHRs in ambulatory care, EHR-related costs reported here are similar while benefits are more favorable.[12] Compared with a recent Connecting for Health report on EHRs in solo or small group practices, net benefits to practices reported here are much higher.[13]

■ **Practice factors affecting costs and benefits.** *Practice use of the EHR.* Almost all of the providers used the EHR for most common activities, a prerequisite for generating EHR benefits; this helps explain the level of financial benefits achieved. Consistent use of EHR templates (forms) to document visit progress notes helped reduce the need for medical records staff and transcription, and the resulting more complete documentation and more thorough visits increased providers' comfort with higher coding levels. Practices that used disease-specific templates were more likely than others to engage in other QI efforts.

Pre-EHR characteristics. Costs depended on the state of existing hardware and support structure in the practice, while financial benefits depended on pre-EHR provider coding styles (conservative versus aggressive). For some practices, effecting some practice changes likely could have been made pre-EHR, but the EHR implementation and the reexamination of processes that accompanied it were catalysts for change.

EHR champion and practice culture. Costs for installation, training, software, hardware, and revenue losses depended heavily on the technical or negotiating savvy of the EHR champion (usually a physician, but sometimes also the office manager or practice administrator). Benefits relied heavily on this person's technical and business skills. Clinical QI gains relied on the physician champion's or practice's interest in QI and willingness to make complementary process changes.[14]

Improving quality of care and notes were the primary stated reasons for initially implementing EHRs. However, stated reasons did not necessarily correspond with EHR-related benefits. For example, most practices that reaped the greatest coding benefits did not consider billing improvement an important motivation, and most practices that had not yet engaged in substantial QI efforts nevertheless considered QI as a primary motivation for EHR implementation.

Group size and duration of EHR use. There was no apparent pattern to results by group size or by duration of EHR use.

EHR vendor software and support. There were no qualitative differences in EHR-related costs or benefits between the vendors. QI-related software limitations were greater for one vendor than for the other, but there were no discernible differences in QI efforts between the two groups of practices. Providers generally were satisfied with the software's usefulness and would not return to paper records, but they wanted more training on how to use the EHR more effectively.

Data exchange/interfaces. We expected greater benefits in practices with practice management systems that were integrated with their EHRs, but no clear pattern emerged from the data. Interviewees reported that lab interfaces were important in avoiding scanning and medical record costs, improving access to data, reducing providers' time spent seeking information, and improving quality of care.

■ **Policy implications.** Different stakeholders can interpret the results of this study differently. From providers' perspective, practices we studied achieved efficient quality improvement: They reduced inefficiencies in providing care and increased quality to some extent. From the same perspective, gains from higher coding levels rewarded providers' initial time costs and financial risk-taking for EHR implementation and corrected flaws in a reimbursement system that encourages providers to code conservatively (undercode) out of concern for "fraud and abuse" penalties.[15] Higher coding levels also reward more thorough visits that can improve quality. In contrast, from payers' perspective, providers achieved inefficient QI since payers paid much more for very modest QI gains.

Coding-related gains are equivalent to a policy whereby payers make bonus payments to practices for adopting EHRs. The primary cause of this unintended policy for EHR adoption is the current reimbursement system, which rewards more extensive coding of specific services but not more extensive provision of high-quality care. With an EHR, some visit coding changes are easy to make and are highly rewarded.

Efficiency changes are harder to make, because they require initial provider time to make process changes, yet such changes also are rewarded financially. In contrast, although QI changes are often the most difficult to make, most physicians receiving fee-for-service payment are scarcely rewarded at all for them. QI requires providers' time and willingness to make complementary practice process changes and to learn about more advanced EHR features. Providers need to revise templates for specific conditions or diseases, establish reminders at the point of care, and create lists to follow up with patients. Lack of reward for difficult tasks helps explain why only two study practices embarked on extensive QI changes.

Performance rewards and support services programs. Few would find fault with rewarding physicians for improved practice efficiency or for more thorough visits resulting from EHR use. In the short run, given the current reimbursement system, also rewarding physicians for simply having an EHR may be acceptable to some, to spur diffusion of EHR innovation. However, over time, policies must deepen providers' efficiency gains and shift toward quality-related, rather than coding-related, revenue gains.

A well-designed quality performance incentive system—emphasizing greater pay-for-performance and less fee-for-service payment—could help correct the problems of outsized coding-related financial gains and undersized QI-related financial gains. Most current pay-for-performance initiatives would benefit EHR-using practices that could more easily capture and report on data, and use reminders and other EHR tools to improve performance, than paper-based practices could. Initiatives offering larger incentives and rewarding a wider array of clinical measures would especially benefit EHR-using practices and increase QI gains. Meanwhile, a policy of promoting well-designed support services for practices could reduce providers' time and financial costs for QI activities and increase the extent their use—and thus increase pay-for-performance payments to practices.

Policy initiatives can build on existing pay-for-performance programs in the private sector but would require accelerating research and demonstrations that address pay-for-performance issues for smaller fee-for-service practices, including ways to assign patients to a particular practice and collect and calculate common measures across multiple health plans.[16] The CMS already is developing and experimenting with several key elements of needed policies. The Medicare Care Management Program demonstration project would test pay-for-performance initiatives for practices receiving fee-for-service payment and provide a layer of technical and office redesign support services.[17] Several Medicare Quality Improvement Organizations (QIOs) have launched Doctor's Office Quality Information Technology (DOQ-IT) programs, which have begun to provide a range of support services to various layers of EHR adopters—considerers, implementers, and users.[18] Moreover, the CMS's Eighth Scope of Work for QIOs will build on the DOQ-IT projects, greatly expand the program, and encourage vendors to alter their software to permit easier and uniform QI reporting.

Technical and office redesign support programs are especially important because they lessen the current heavy reliance on physicians' technical and business savvy for lowering costs and increasing benefits. Support programs could help all physicians, especially those who are less proficient in effecting technical or process changes. However, support programs must be highly efficient and effective, since they consume providers' resources as well as those of the CMS/ QIOs, and time is money for most solo or small-group physicians. Both pay-for-performance and support-services programs would stimulate even greater efforts by software vendors to make their software easier to use, including for QI, which would speed the realization of benefits.

RHIOs. Funding for more rapid expansion of regional health information organizations (RHIOs) and other entities that can enable electronic clinical data exchange, ordering, and messaging would especially benefit solo or small group practices with EHRs by decreasing the costs of document scanning and data entry and providers' time to access information.

■ **Study limitations.** This qualitative study has several limitations. We obtained data from a small sample of fourteen practices using EHRs from two vendors. By design, participating practices were primary care, had used EHRs for one to three years, were not start-up practices, were already full, and had mostly stable provider complements over time. Study practices may not be representative of other practices using the same EHR products or of practices using software from other vendors. Moreover, other vendors can have somewhat different product pricing, capabilities, training, and support policies, although the two EHR vendors and products in this study were not atypical. The survey did not include practices that had implemented EHRs and then returned to paper. Given the spectrum of innovation adopters, study practices likely differ in important ways from practices considering EHRs (but have yet to adopt them) and even more from practices not yet considering EHRs.

Overall, participating practices likely were more successful than those that did not participate, while the study's early-adopting practices may be more enthusiastic about EHRs (and generate more benefits) than will newly adopting practices—which could result in overestimates of EHRs' financial benefits. Nevertheless, the benefits of EHRs may increase over time as pay-for-performance spreads, support services increase, EHR technology improves, and practices gain experience in using EHRs effectively.

Among other limitations, data were mostly self-reported and thus might not have captured some EHR-related effects on visit productivity, where even small changes can have large effects on benefits or costs. Clearly, data are urgently needed from much larger surveys that also use several methods and have a stronger quantitative focus.

Our study suggests that EHRs are financially attractive for some solo or small group practices and financially acceptable for most others; this assumes that the next layer of physician EHR adopters is not radically dissimilar from the early adopters. However, substantial revenue gains from coding increases and limited QI activities lower the value of EHRs in solo or small practices to payers, motivating policies that provide performance incentives and practice support services to spur EHR adoption and use for efficient quality improvement.

The primary funding source for this study was the Commonwealth Fund.

NOTES

1. American Medical Association, *Physician Socioeconomic Statistics, 2000–2002 Edition* (Chicago: AMA, 2001).
2. M.C. Reed and J.M. Grossman, *Limited Information Technology for Patient Care in Physician Offices* (Washington: Center for Studying Health System Change, September 2004); Connecting for Health, *Financial, Legal, and Organizational Approaches to Achieving Electronic Connectivity in Healthcare*, October 2004, www.connectingforhealth.org/assets/reports/flo_sustain_healthcare_rpt.pdf (28 June 2005); R.H. Miller and I. Sim, "Physicians' Use of Electronic Medical Records: Barriers and Solutions," *Health Affairs* 23, no. 2 (2004): 116–126; and Office of the National Coordinator for Health Information Technology, *Progress Report July 21, 2004: Framework for Strategic Action* (Washington: ONCHIT, 2004).
3. For peer-reviewed literature, see, for example, S.J. Wang et al., "A Cost-Benefit Analysis of Electronic Medical Records in Primary Care," *American Journal of Medicine* 114, no. 5 (2003): 397–403. For an example of reports relying on expert opinion, see Connecting for Health, *Financial, Legal, and Organizational Approaches.*
4. E.M. Rogers, *The Diffusion of Innovations*, 4th ed. (New York: Free Press, 1995).
5. Miller and Sim, "Physicians' Use of Electronic Medical Records"; and R.H. Miller, I. Sim, and J. Newman, *Electronic Medical Records: Lessons from Small Physician Practices*, October 2003, www.chcf.org/documents/ihealth/EMRLessonsSmallPhyscianPractices.pdf (28 June 2005).
6. Hardware included computer equipment (desktops, notebooks, servers, storage), related ancillary equipment (printers, scanners, monitors), and networking (routers, wiring); hardware replacement costs assume a four-year life for initial hardware and continued decreases in hardware costs over time; because of differences in pre-EHR hardware, replacement costs were estimated as an average per provider across practices, not by practice. Software included license or maintenance costs for EHR or related software (for interfaces, databases). IS staff and external IT contractor costs included increases resulting from the EHR. Installation included vendor and contractor costs for installing software. Since several practices' contracts did not consistently separate software, installation, and training costs, we combined them. Revenue losses at implementation were attributable to provider productivity decreases resulting from reduced visit schedules. "Other" costs included initial data abstraction costs and extra telecommunication costs.
7. S. Barlow, J. Johnson, and J. Steck, "The Economic Effect of Implementing an EMR in an Outpatient Clinical Setting," *Journal of Healthcare Information Management* 18, no. 1 (2004): 46–51.
8. Benefits estimates likely are conservative, since they exclude benefits that respondents described only qualitatively (increase, large increase). Applying a discount rate (4–8 percent) to determine the present value of costs and benefits in later years did not greatly affect results.
9. For example, see "Overview of the Chronic Care Model," www.improvingchroniccare.org/change/model/components.html (27 July 2005).
10. Among "other" initial costs, chart abstraction costs were only 1 percent of the total, because providers almost always entered past clinical data during the patient's initial visit after implementation, instead of populating the database in advance.
11. Wang et al., "A Cost-Benefit Analysis."
12. Miller and Sim, "Physicians' Use of Electronic Medical Records."
13. Connecting for Health, *Financial, Legal, and Organizational Approaches.*
14. In solo practices, champion and group characteristics are almost synonymous.
15. J.A. Kusske, "Physicians under Fire: Waging the War on Fraud and Abuse," *American Association of Neurological Surgeons Bulletin* 9, no. 2 (2000): 5–11.
16. A.M. Epstein, T.H. Lee, and M.B. Hamel, "Paying Physicians for High-Quality Care," *New England Journal of Medicine* 350, no. 4 (2004): 406–410; and M.B. Rosenthal et al., "Paying for Quality: Providers' Incentives for Quality Improvement," *Health Affairs* 23, no. 2 (2004): 127–141. See also the Leapfrog Group's compendium of pay-for-performance efforts, at ir.leapfroggroup.org/compendium/compendiumsearch.cfm (27 March 2005).
17. See Medicare Payment Advisory Commission, *Report to the Congress: Medicare Payment Policy*, March 2005, www.medpac.gov/publications/congressional_reports/Mar05_TOC.pdf (27 March 2005).
18. For more information, see the Doctor's Office Quality Information Technology home page, www.doqit.org (27 July 2005).

MARKETWATCH

The Value Of Electronic Health Records In Community Health Centers: Policy Implications

Although EHRs are still not paying for themselves, they have helped improve quality of care in community health centers.

by Robert H. Miller and Christopher E. West

ABSTRACT: This paper analyzes the costs and benefits of electronic health records (EHRs) in six community health centers (CHCs) that serve disadvantaged patients. EHR-related benefits for most study CHCs did not pay for ongoing EHR costs, yet quality improvement (QI) was substantial. Compared to private practices, CHCs cannot use EHRs to increase visit coding levels and revenues, yet they likely use EHRs more aggressively for QI, which raises equity questions. The evidence suggests that policies are needed that help CHCs to afford EHRs and produce more EHR-related QI gains, including through grants and QI performance rewards. [*Health Affairs* 26, no. 1 (2007): 206–214; 10.1377/hlthaff.26.1.206]

Community health centers (CHCs) are a major source of primary care for disadvantaged U.S. populations. In 2004, 914 federally qualified health centers (FQHCs) provided medical and dental primary care services to 13.1 million patients, of whom 40 percent were uninsured and 36 percent were covered by Medicaid; 70 percent had below-poverty incomes, and 63 percent were nonwhite.[1] Almost 10,000 full-time-equivalent (FTE) physicians, nurse practitioners, physician assistants, and certified nurse midwives provided care. FQHCs received $6.7 billion in revenues—mostly from Medicaid reimbursement and grants, especially from the Bureau of Primary Health Care (BPHC) in the Health Resources and Services Administration (HRSA). CHC "look-alikes" that operate without federal grants serve millions more patients.

A small but growing number of CHCs use electronic health records (EHRs), which promise to improve quality, especially for preventive and chronic care. This paper describes the value of EHRs in six CHCs. We were most interested in EHRs' effect on finances, given CHCs' limited financial resources, and on quality improvement (QI), given that their mission has led CHCs to be relatively aggressive in improving quality of care for the disadvantaged.[2]

Study Data And Methods

We conducted retrospective qualitative case studies of six CHCs with EHRs in six states, obtaining data for May 2004–June 2005. We adapted methods from our prior studies on EHRs in large groups and solo or small group practices.[3]

We defined the value of the EHR as the ratio of EHR-related benefits to costs—of efficiency, revenue, quality, and access gains to fi-

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nancial, provider time, and management time costs. Although some CHCs provide their own EHR services, others contract with network application systems providers (network ASPs) that help CHCs implement and use EHRs and charge fees for their services.

We selected a purposeful sample of six CHCs with EHRs that were diverse in key characteristics that could affect EHR value, based on previous studies—size (15–50 providers), geography (six states with different Medicaid reimbursement systems), EHR vendors (four), and duration of use—plus whether or not a network ASP provided EHR services. We identified potential cases from public presentations by CHC managers and from discussions with BPHC managers and other CHC experts. Four CHCs implemented EHR services without network ASP support: the Institute for Urban Family Health (IUFH) in New York City (six CHC clinics serve the disadvantaged, and seven IUFH-managed clinics serve privately insured patients); Heart of Texas (HOT) Community Health Center in Waco, Texas; Waianae Coast Comprehensive Health Center in Hawaii; and Community Health Association of Spokane (CHAS), Washington.

Two CHCs were members of network ASPs: Family Health Centers of Southwest Florida in Fort Myers, a member of Health Choice Network (HCN) whose twenty-one CHCs had more than 200 FTE billing providers; and Lamprey Health Systems in New Hampshire, a member of the Community Health Access Network (CHAN) whose members had more than forty FTE providers. Of three other CHCs approached, two provided only initial information, including one that had severe problems implementing an immature software product; one did not respond.

We also obtained data from two network ASPs preparing to implement EHRs, to help estimate EHR replacement costs for CHCs whose historical costs were out of date. Chicago Alliance network data helped estimate CHAN-Lamprey EHR replacement costs, since both had the same EHR, similar size, and network ASP models. We created a composite case (CHAN-Lamprey/Chicago). Data from the Oregon Community Health Information Network (OCHIN) helped estimate EHR replacement costs for HOT and improve estimates for IUFH, which had the same EHR. Since financial costs were more precise than benefits, we created a range of estimates for some benefit components.

We used a detailed, semistructured questionnaire to conduct more than sixty interviews of key CHC personnel most knowledgeable about EHRs in their CHC/network, including medical directors, executive directors, chief financial/operating officers, EHR project team leaders, and QI staff leaders. We summarized more than eighty hours of taped and transcribed interviews into tables, using concept categories developed in prior work (for example, implementation method and QI activities). Pattern-matching and explanation-building techniques helped identify new themes and patterns in the data.[4]

Study Results

■ **CHC characteristics.** Study CHCs were larger than average and had diverse characteristics (Exhibit 1). EHR experience varied from one to eight years among the five fully implemented CHC cases; half of the Fort Myers providers were using fully implemented capabilities as of spring 2005.

Study cases used four EHR software products: EpicCare from Epic Systems (IUFH, HOT); NextGen from NextGen Healthcare Systems (Quality Systems Inc.) (Waianae, CHAS); Centricity from GE (CHAN-Lamprey/Chicago); and Intergy from Emdeon (WebMD) Practice Services (HCN–Fort Myers). Software had similar capabilities, although Fort Myers' EHR lacked reporting capabilities, except in beta. Most CHCs created two-way data exchange between EHR and practice management systems for billing, scheduling, and registration data and between EHR and lab information systems.

Network ASP staff provided a layer of services between CHC members and vendors: They selected the EHR, negotiated vendor contracts, configured and hosted central soft-

EXHIBIT 1
Characteristics Of Study Community Health Centers (CHCs), 2004

	IUFH (CHC sites only)[a]	HCN-Fort Myers	HOT	CHAN-Lamprey	CHAS	Waianae	National average
No. of sites	6	11	8	3	4	4	
No. of encounters	57,968	139,642	118,188	60,120	66,924	102,054	43,301
No. of FTE providers	15.6	33.5	40.9	15.6	21.3	37.0	11.3
MDs	11.9	17.1	18.6	8.1	4.7	24.4	7.3
Mid-levels	3.7	16.4	22.3	7.5	16.6	12.6	4.0
Ratio MDs/mid-levels	3.2	1.0	0.8	1.1	0.3	1.9	1.8
Encounters per FTE	3,715	4,081	2,889	3,854	3,075	2,758	3,395
Encounters							
Medicaid	43%	30%	41%	16%	42%	50%	36%
Uninsured	19	51	36	34	47	17	40
Patient revenues (percent of total)							
Private insurance	18%	5%	11%	37%	3%	16%	11%
Medicare	4	8	15	13	4	10	10
Medicaid	70	53	63	41	74	71	64
Self-pay	6	26	7	9	6	2	11
Total	98	92	96	100	87	99	96
Cost per encounter—medical	$141	$89	$114	$124	$101	$132	$109
Total revenues (millions)	$11.205	$17.300	$18.245	$8.640	$12.671	$21.540	$7.310
Patient revenues (millions)	$6.944	$10.930	$12.128	$3.970	$9.484	$16.690	$4.170
Time since first implementation (years)	2.5	1.5[b]	8	6	4	2	–[c]
Software used	EpicCare	Intergy	EpicCare	GE Centricity	NextGen	NextGen	–[c]

SOURCE: Authors' study data.
NOTES: IUFH is Institute for Urban Family Health. HCN-Fort Myers is Health Choice Network—Family Health Centers of Southwest Florida. HOT is Heart of Texas Community Health Center. CHAN-Lamprey is Community Health Access Network/Lamprey Health Systems. CHAS is Community Health Association of Spokane (Washington). Waianae is Waianae Coast Comprehensive Health Center. FTE is full-time-equivalent.
[a] CHC sites only—IUFH managed seven clinics that serve privately insured patients.
[b] Still implementing.
[c] Not applicable.

ware, developed templates (electronic forms), trained providers/staff, installed EHR software, provided help-desk support, and assisted with EHR-related process/workflow redesign and QI activities.

CHCs (including those using network ASPs) financed EHRs through operating funds and such sources as federal government grants (five CHCs) and vendor-supplied free software licenses and discounts to CHC "early adopters" or software codevelopers (two CHCs).

■ **Financial costs and benefits.** Initial EHR costs per FTE billing provider averaged almost $54,000 ($16.20 per visit), with much variation among CHCs and within each cost category (Exhibit 2). Ongoing costs per FTE provider per year averaged $20,610 ($6.21 per visit). One case reported sizable financial benefits ($20,000 per billing provider per year, which covered ongoing costs), three reported benefits that were less than ongoing costs, and two reported few or no benefits.

Financial benefits were attributable mostly to efficiency gains, especially reduced medical record and transcription costs; some medical record efficiency gains might have been masked by a shift of resources into QI. For example, IUFH medical record staff that no longer pulled charts (an efficiency gain) spent freed-up time obtaining more complete information from consultants and other sources (a QI gain). Documented provider productivity gains were negligible, although two cases

EXHIBIT 2
Initial And Ongoing Electronic Health Record (EHR) Costs Per Full-Time-Equivalent (FTE) Provider In Six Community Health Centers (CHCs), By Cost Category, 2004–05

	IUFH	HCN-Fort Myers	HOT	CHAN-Lamprey/ Chicago	CHAS	Waianae	Average Cost	Average Percent
Initial								
Hardware	$27,591	$ 6,820	$30,389	$ 8,575	$15,000	$13,757	$17,022	30.6
Software	26,342	11,650	22,954	12,159	8,560	12,514	15,697	28.2
Installation, training	10,248	10,922	6,826	24,213	11,085	8,700	11,999	21.6
Productivity loss	10,000	2,000	1,976	8,000	5,226	3,378	6,763	12.2
Other (including telecom)	0	985	4,491	11,860	5,630	2,019	4,164	7.5
Total	74,181	32,379	66,637	64,804	45,501	40,368	53,978	100.0
(Total per medical encounter)	19.96	7.93	23.06	16.81	14.79	14.63	16.20	
Ongoing								
Hardware	4,828	1,705	7,597	2,144	3,750	3,439	3,911	19.0
Software maintenance	5,532	2,607	3,054	2,267	1,541	3,054	3,009	14.6
IS staff, contractors, training	14,621	9,061	6,557	15,160	10,250	11,932	11,263	54.6
Other	1,710	1,408	2,283	2,507	4,574	2,081	2,427	11.8
Total	26,691	14,780	19,491	22,077	20,115	20,507	20,610	100.0
(Total per medical encounter	7.18	3.62	6.75	5.73	6.54	7.44	6.21	

SOURCE: Authors' study data.
NOTES: For CHC information, see Exhibit 1. IS is information services.

speculated about possible (but not confirmed) gains of 1–5 percent. CHAS reported $6,000 per FTE billing provider in utilization savings for Medicaid patients capitated for hospital and full professional services; other CHCs had few capitated CHC patients.

Revenue enhancement benefits were negligible. CHCs could not use EHRs to increase visit coding levels because Medicaid paid most CHCs a flat rate per visit, while the BPHC paid CHCs an annual lump sum for uninsured care; meanwhile, CHCs received few pay-for-performance (P4P) incentives.

Overall, evidence suggests that all but one study case incurred ongoing net financial losses, ranging from a few thousand to more than twenty thousand dollars per FTE billing provider, and that no case had yet paid for any initial EHR costs, excluding special EHR grant funding. Using optimistic assumptions about financial benefits, at least three CHCs incurred substantial ongoing financial losses. To establish the "true" value of EHRs to CHCs, other costs and benefits must be considered.[5]

■ **EHR use for QI.** *Overview.* Study CHCs made many QI changes that incorporated methods learned in Health Disparities Collaboratives (HDCs). HDCs encourage implementation of the Care Model, which reorients clinical practice toward chronic/preventive care; clinical information systems (CIS) (such as EHRs) are a key Care Model component.[6]

All CHCs extensively used basic EHR capabilities—that is, virtually all providers electronically viewed data (such as lab results); maintained coded lists of patient problems, services provided, medications, and allergies; used templates (electronic forms) to generate prescriptions and lab orders and to document treatment progress.

Five of six CHCs extensively used EHR registry and chronic disease management/ preventive care capabilities in at least several clinical priority areas: Health Plan Employer Data and Information Set (HEDIS) reporting requirements and HDC participation influenced priority area choices (Exhibit 3).

QI changes in priority areas. (1) Data capture

EXHIBIT 3
Quality Improvement (QI) Priority Areas In Six Community Health Centers (CHCs) With Electronic Health Records (EHRs), 2004–05

	IUFH	HCN-Fort Myers	HOT	CHAN-Lamprey	CHAS	No. of CHCs
Preventive care						
Lead screening	●			●		2
Childhood development screening	●					1
Childhood immunizations[a]	●	●	●	●	●	5
Flu vaccine[a]	●	●	●	●	●	5
Pneumonia vaccine	●	●	●	●		4
Metabolic syndrome screening			●	●		2
Hypertension screening	●					1
LDL screening–for general population	●					1
Colon cancer screening[a]	●	●				2
Mammograms (breast cancer screening)[a]	●	●	●	●		4
Pap smear (cervical cancer screening)[a]	●	●	●	●		4
Mental health/depression screening		●			●	2
Gynecological infections[a]			●	●		2
OB patients and dental visits					●	1
Childhood obesity					●	1
Chronic care (with selected measures)						
Asthma (peak flow)[a]	●	●		●	●	4
Depression/mental health[a]	●	●			●	3
Kidney function/creatinine measurement	●					1
HIV	●	●			●	3
Hepatitis C					●	1
Cardiovascular disease						
Hypertension[a]	●	●		●		3
LDL screen/hyperlipidemia/statin use[a]	●	●		●		3
Antithrombolytic agent (aspirin) use		●		●		2
Diabetes	●	●	●	●	●	5
HbA1c testing[a]	●	●	●	●	●	5
Retinopathy screenings[a]	●	●	●			3
Foot checks		●	●	●	●	4
Nephropathy/renal testing[a]	●	●	●	●		4
LDL screening[a]	●	●	●	●		4
Hypertension checks	●	●	●	●	●	5
Total priority areas[b]	17	14	8	13	10	62

SOURCE: Authors' study data.
NOTES: For CHC information, see Exhibit 1. LDL is low-density lipoprotein. OB is obstetrical.
[a] Health Plan Employer Data and Information Set (HEDIS) focus area.
[b] Diabetes is counted as a single area.

using templates: In addition to coded lists, providers in all CHCs routinely used condition-specific templates (electronic forms) to document at least some chronic or preventive care visits; providers in three CHCs routinely used templates to capture coded encounter data useful for reporting. (2) Reminders at the point of care: Most providers received CHC-set reminders for patients needing services in at least some priority clinical areas. IUFH used reminders most heavily, most of which resulted in measurable performance gains.

(3) Lists of patients needing services: Four CHCs generated lists of patients needing chronic/preventive care services, and three CHCs systematically followed up with patients on lists. For example, CHAN-Lamprey case managers contacted patients needing diabetic services, immunizations, and flu vaccinations. (4) Performance reports: Managers saw

performance reports as pivotal for QI. Four CHCs regularly generated reports for at least some priority clinical or efficiency areas. CHAS used performance reports to create QI financial incentives for staff and providers in five clinical areas, while CHAN-Lamprey provided smaller incentives to individual physicians. (5) Patient self-management: CHCs made limited use of patient self-management capabilities. Two provided printed patient visit summaries; another provided individualized self-care plans to asthma and depression patients.

Combinations and focus of QI changes. Typically, CHCs made several systematic QI changes in each priority area, and they emphasized some changes more than others. For example, HOT encouraged providers to use diabetes templates, "turned on" reminders for overdue diabetes tests, sent providers reports comparing their performance treating diabetics with that of peers, generated lists of diabetics needing services, and assigned nurse case managers to follow up with patients on lists. Despite their satisfaction with sizable EHR-related QI gains, interviewees felt that they were only beginning to use the EHR effectively for QI.

■ **Other benefits.** Interviewees also mentioned using improved data and analysis tools to obtain new grants, attract new research funding, better manage satellite clinics, expand to new sites, and coordinate care for patients visiting several sites.

■ **Value of EHRs without policy changes.** Most or all of the CHCs we studied incurred net financial losses from EHR use, as a result of high initial and ongoing EHR costs and limited financial benefits. Yet most CHCs also launched EHR-enabled QI changes that likely generated sizable QI gains. As a result, EHR value to CHCs was mixed, with a trade-off of financial losses for QI gains.

In contrast, EHRs in CHCs were a clear value to patient and payer stakeholders, since patients received better care, and payers likely reaped some EHR-related downstream benefits in avoided specialist, emergency room (ER), and hospital spending—at no added cost to them. The value of such benefits was mixed for hospitals receiving fee-for-service payment—decreased revenues for the insured, decreased costs for the uninsured.

Several trends are likely to increase EHR value to CHCs without policy changes. EHR costs will decrease and benefits increase as more network ASPs reap economies of scale in IS staffing, software pricing, and learning; as later adopters benefit from earlier implementation investments and lessons learned; as CHCs learn to use EHRs more effectively; and as CHCs, network ASPs, and learning groups identify and disseminate "best practices" for reaping benefits. CHC managers were optimistic about further EHR-related gains. Nevertheless, despite promising trends and QI gains, in the near future EHRs likely will remain a mixed or poor financial value for many CHCs, absent policy changes.

■ **EHR value in CHCs compared to private practices.** Compared with another study of fourteen solo or small group practices with EHRs that we conducted using similar methods, CHCs had higher EHR costs and lower financial benefits, and they made much greater QI efforts. EHR initial costs for CHCs were about $10,000 higher per FTE provider, and ongoing costs were more than double those of solo or small group practices (because of greater complexity). Meanwhile, flat-rate or lump-sum reimbursement methods prevented CHCs from obtaining substantial billing coding gains available to private practices, while concerns about staff layoffs and QI meant that CHCs often invested efficiency gains in QI, rather than pocketing gains.[7] Finally, although differences in sample size and selection between studies make precise comparisons impossible, five of six study CHCs made substantial, multifaceted systematic QI changes, compared with only two of fourteen solo or small group practices with EHRs. Without P4P incentives, CHCs could not turn this QI advantage into financial gains.

Discussion And Policy Implications

■ **Barriers to improved EHR value specific to CHCs.** Most barriers to improving EHR value are not unique to CHCs—for example, high EHR cost, difficulty in effecting changes, and lack of regional electronic data exchange.[8] In addition to the inadequate reimbursement methods discussed above, two other barriers are attributable to the CHCs' focus on disadvantaged patients.

Complexity. Compared with most private practices, CHCs serve more-challenging patients with less education, income, insurance, and English language proficiency and more chronic care, psychological, and other health problems.[9] As a result, CHCs are organizationally more complex, with more small sites to increase access and more "one-stop shopping" for medical, dental, mental health, and substance abuse services and "wraparound" nutrition, health education, and other services.[10] Meanwhile, aggressive focus on QI requires process changes, which adds to complexity. This complexity increases EHR-related costs for CHCs, because it increases the complexity of CIS changes, staff training, and complementary process changes.

Resources. Compared with similar-size private organizations, CHCs tend to be chronically short of financial resources, which slows EHR adoption; among EHR adopters, it makes it more difficult to afford appropriate information systems and other staff needed to make the many CIS and process changes required to effectively use EHRs for QI.[11]

■ Facilitators for increasing EHR value in CHCs. Compared with most private practices, unique CHC advantages—mission and HRSA/BPHC-promoted networks and collaboratives—can reduce EHR-related costs and increase benefits. Mission to serve the disadvantaged focuses CHCs' attention on QI and motivates grants for new CIS/QI initiatives from foundations and government funding agencies. As a result of HRSA/BPHC efforts to facilitate cooperative efforts among organizations, networks of CHCs have begun providing members common services (including for EHRs) that benefit from economies of scale and more "learning-by-doing" opportunities.[12] Moreover, HRSA/BPHC efforts to promote QI, including through HDCs, have helped CHCs to acquire QI organizational change tools, use less complex registry CIS, and create more systematic processes, laying the groundwork for EHR use for QI.

■ Implications for policy changes. Without policy changes, most CHCs adopting EHRs likely will struggle to pay for them, even while improving quality, which inevitably would lead to cutbacks in EHR use or in other areas. Given limited resources, many CHCs will delay adopting EHRs because they cannot produce sufficient EHR-related QI gains rapidly enough to justify the unfavorable financial return on investment, reducing potential QI gains for the disadvantaged.

Equity questions arise because EHRs in private medical groups might make sense financially and yet might have a limited effect on increasing social good, whereas EHRs in CHCs might not make sense financially (to CHCs) and yet might do more social good.[13] By "social good," we mean net EHR-related benefits to all stakeholders combined, including reduced health disparities for the disadvantaged. These findings suggest the need for innovative ways to fund EHRs in CHCs through public and foundation means.

Making some rough assumptions, CHCs will need \$550 million–\$1.1 billion, or \$55–\$110 million per year spread over ten years, to pay for EHRs, including technical and organizational assistance. Assumptions include a ten-year EHR implementation period in the CHC sector, \$35,000–\$50,000 per FTE provider in initial costs, and an average \$5,000–\$15,000 per provider net annual loss (cost) in the first four years post-implementation.

Policy approaches need to help CHCs pay for EHRs while accelerating CHCs' use of EHRs for QI, where much of the benefit lies. One policy approach puts great emphasis on Health and Human Services (HHS) leadership and financial resources.[14] However, in an era of budget deficits, few domestic program initiatives, and relatively little federal funding for CIS initiatives, it is prudent to also look elsewhere for funding.

Grants with QI incentives. Funding agencies can use grants with QI incentives to help pay for EHRs in CHCs, while increasing the pace of EHR-enabled QI. Although only the federal government has the potential resources to play an important national role in EHR funding, large national foundations could help finance demonstration projects. Regional foundations, including ones formed from health care conversions, and state legislative programs with line items for CIS in CHCs could help fund EHRs in CHCs, ideally partnering with HRSA.[15] Funding-agency consortia that coordinate funding could finance larger projects for networks of CHCs.

Pay-for-performance. Centers for Medicare and Medicaid Services (CMS) and state Medicaid P4P policies can help finance EHRs by rewarding CHCs for EHR-related QI benefits that create "downstream" benefits for Medicaid payers. This would increase the pace of CHCs' EHR use for QI, creating even more "downstream" benefits. Some Medicaid managed care health plans have begun to provide rewards, but more initiatives are needed.[16] Absent P4P, Medicaid agencies should include CHCs' EHR costs in prospective payment system (PPS) reimbursement calculations.

Network ASPs. Network ASPs can compensate for individual CHC resource shortages by enabling CHCs to "buy" services that they could not "make" or make efficiently—which is especially important for the many CHCs that are smaller, have fewer organizational resources, and have less capacity for organizational learning than the CHCs we studied. Network ASPs can help CHCs benefit from economies of scale (especially for software pricing and IS staffing), from more efficient learning through sharing of insights about what "works," and from services that go beyond those typically offered by commercial ASPs, especially for ongoing training, process change and technical support, and QI. Funding agencies can provide grants for some network costs and for some CHC fees paid to network ASPs—with QI incentives attached.[17]

Improved CHC preparation for EHRs. Policies that help CHCs increase their "readiness" for EHR implementation can assist more CHCs to produce EHR-enabled QI rapidly enough to justify the cost.[18] Implementing increasingly sophisticated registry CIS software—that is less robust than EHRs but still supports QI—can help prepare CHCs for greater changes needed for effective EHR use for QI.[19]

More effective data use. HRSA and other funding agencies should support CHCs' efforts to use common QI performance measures and methods that enable performance benchmarking, public performance reporting, performance incentives, improved population management, and research/evaluation. *Consumer Reports*–style assessments could compare network ASP and EHR vendor performance.

Cooperative learning efforts. Learning groups consisting of CHCs/network ASPs with EHRs can facilitate systematic learning and "push the envelope" of effective EHR use for QI. Grant-making agencies should fund staff time to support learning groups and manager time to share their insights.

■ **Study limitations.** This retrospective, qualitative study obtained data from a small, purposeful sample of six CHCs, with additional information from two network ASPs. Study CHC cases likely were more successful than cases that declined to participate. These "early adopter" cases might be more successful than the next layer of CHCs, although CHC EHR costs likely will decrease and benefits increase somewhat over time. Data were mostly self-reported, were more precise for costs than benefits, and might not have captured some EHR-related effects on visit productivity. CHCs are dynamic, growing organizations, which complicated our determination of EHRs' effects. Urgently needed are studies that use qualitative and quantitative methods to evaluate CHCs with EHRs and network ASPs and that determine "downstream" financial benefits attributable to EHR-related QI.

THE HEALTH CENTERS in this study incurred EHR-related financial losses, even while substantially increasing quality for the disadvantaged. The evidence suggests that for CHCs to afford EHRs—and produce more EHR-related QI gains—CHCs will need much external support, including through grants and P4P incentives that reward CHCs for EHR-enabled QI gains and "downstream" financial benefits.

Analyzing the value of EHRs in CHCs inevitably raises questions about the overall value of CHCs. The need to determine, increase, and fairly pay for the value of EHRs in CHCs can help the effort to determine, increase, and fairly pay for the value of CHCs in the health care system.

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NOTES

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SPECIAL ARTICLE

Electronic Health Records in Ambulatory Care — A National Survey of Physicians

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ABSTRACT

BACKGROUND

Electronic health records have the potential to improve the delivery of health care services. However, in the United States, physicians have been slow to adopt such systems. This study assessed physicians' adoption of outpatient electronic health records, their satisfaction with such systems, the perceived effect of the systems on the quality of care, and the perceived barriers to adoption.

METHODS

In late 2007 and early 2008, we conducted a national survey of 2758 physicians, which represented a response rate of 62%. Using a definition for electronic health records that was based on expert consensus, we determined the proportion of physicians who were using such records in an office setting and the relationship between adoption and the characteristics of individual physicians and their practices.

RESULTS

Four percent of physicians reported having an extensive, fully functional electronic-records system, and 13% reported having a basic system. In multivariate analyses, primary care physicians and those practicing in large groups, in hospitals or medical centers, and in the western region of the United States were more likely to use electronic health records. Physicians reported positive effects of these systems on several dimensions of quality of care and high levels of satisfaction. Financial barriers were viewed as having the greatest effect on decisions about the adoption of electronic health records.

CONCLUSIONS

Physicians who use electronic health records believe such systems improve the quality of care and are generally satisfied with the systems. However, as of early 2008, electronic systems had been adopted by only a small minority of U.S. physicians, who may differ from later adopters of these systems.

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Health-information technology, such as sophisticated electronic health records, has the potential to improve health care.[1-3] Nevertheless, electronic-records systems have been slow to become part of the practices of physicians in the United States.[4,5] To date, there have been no definitive national studies that provide reliable estimates of the adoption of electronic health records by U.S. physicians. Recent estimates of such adoption by physicians range from 9 to 29%.[4,5] These percentages were derived from studies that either had a small number of respondents or incompletely specified definitions of an electronic health record.[5,6]

To provide clearer estimates of the adoption of electronic-records systems by U.S. physicians, the Office of the National Coordinator for Health Information Technology of the Department of Health and Human Services[4] supported our project to develop and test measures of adoption and to deploy those measures in a representative national survey of U.S. physicians. The goal was both to gather accurate information on current levels of adoption and to provide survey items that could be used to generate similar data over time on the diffusion of electronic health records and on physicians' perceptions of the effect of such systems on their practices.

This report addresses the following questions: What proportion of physicians report that outpatient electronic health records are available to them in office practice? How satisfied are physicians who use such systems, and what effect, if any, do they believe these systems have on the quality of care they provide to their patients?

METHODS

SURVEY DEVELOPMENT

The survey was developed by the investigators, with guidance from a consensus panel of experts in the fields of survey research, health-information technology, and health care management and policy and from representatives of hospital and physician groups and organizations. The development of the survey was also informed by focus groups and interviews with physicians and chief information officers and by a systematic review of previous surveys that were focused on the adoption of electronic health records.[4]

The survey was approved by the institutional review board at Massachusetts General Hospital and by the federal Office of Management and Budget. The investigators drafted the manuscript and had complete independence in developing the survey, collecting and analyzing the data, and reporting the results.

DEVELOPING A MEASURE OF ADOPTION

On the basis of advice from the expert panel, the investigators defined the key functions that constitute an outpatient electronic health record and asked respondents to describe the availability and use of those functions. The investigators began with the Institute of Medicine's framework that defines possible functions of an electronic health record.[7] Using a modified Delphi process, the panel reached consensus on functions that should be present to qualify the system as a "fully functional" electronic health record.[2] These functions generally fall into four domains: recording patients' clinical and demographic data, viewing and managing results of laboratory tests and imaging, managing order entry (including electronic prescriptions), and supporting clinical decisions (including warnings about drug interactions or contraindications). Physicians were asked whether their main practice site had a computerized system for each function (Table 1).

Recognizing that relatively few physicians might have fully functional electronic health records and that less complete electronic records might nevertheless convey benefits for patients' care, the investigators defined a minimum set of functions that would merit the use of the term "electronic health record," calling this a "basic" system (Table 1). The principal differences between a fully functional system and a basic system were the absence of certain order-entry capabilities and clinical-decision support in a basic system. The survey assessed physicians' access to various functions and whether the functions were used. However, since the overwhelming majority of physicians said they used most available functions, we primarily report findings on the availability of electronic health records in the office setting.

SURVEY SAMPLE

We identified all U.S. physicians who provide direct patient care from the 2007 Physician Masterfile of the American Medical Association (AMA).

Table 1. Survey Items Defining the Use of Electronic Health Records.

Survey Response	Basic System	Fully Functional System
Does your main practice site have a computerized system for any of the following?		
Health information and data		
Patient demographics	X	X
Patient problem lists	X	X
Electronic lists of medications taken by patients	X	X
Clinical notes	X	X
Notes including medical history and follow-up		X
Order-entry management		
Orders for prescriptions	X	X
Orders for laboratory tests		X
Orders for radiology tests		X
Prescriptions sent electronically		X
Orders sent electronically		X
Results management		
Viewing laboratory results	X	X
Viewing imaging results	X	X
Electronic images returned		X
Clinical-decision support		
Warnings of drug interactions or contraindications provided		X
Out-of-range test levels highlighted		X
Reminders regarding guideline-based interventions or screening		X

We excluded all doctors of osteopathy, residents, physicians working in federally owned hospitals, those with no listed address, those who requested not to be contacted, and those who were retired. From the resulting list, we randomly selected 5000 physicians for inclusion in the sample.

Of these 5000 physicians, 516 were ineligible to participate in the survey because they were deceased, retired, out of the country, practicing in a specialty that was not included in the survey (i.e., radiology, anesthesiology, pathology, or psychiatry), had no known address, or were not providing care to patients. Of the 4484 eligible respondents, 2758 completed the survey, which yielded a response rate of 62%. A copy of the survey appears in the Supplementary Appendix, available with the full text of this article at www.nejm.org.

SURVEY ADMINISTRATION

RTI International administered the survey between September 2007 and March 2008. Physicians received an initial mailing that included a cover letter, the survey, a postage-paid return envelope, and a check for $20. Nonrespondents received reminders by mail and telephone. In January 2008, nonrespondents received another reminder and a $40 check to encourage participation.

STATISTICAL ANALYSIS

All statistical analyses were conducted by researchers at Massachusetts General Hospital. We compared the characteristics of respondents with those in the AMA Masterfile using two-tailed chi-square tests with the use of SAS software, version 9.0 (Table 2).[8] The respondents were more likely to be male than would be expected on the basis of national statistics. We adjusted for possible nonresponse bias as a result of this difference by creating a weight equal to the inverse of the response probability for men and women and used this weight in all the multivariate analyses.

We examined the univariate and bivariate relationships in the data. On the basis of these analyses, we applied a cumulative logit model, using SUDAAN, version 9.0.1 (RTI International),[9] to evaluate the association between the characteristics of physicians (sex, race and ethnic background, number of years in practice, and medical specialty) and their practices (practice size, practice setting, location, and region of the country) with the availability of electronic health records, which was treated as an ordinal variable. From this model, we obtained percentages[10] and the accompanying standard errors of availability of electronic health records, with adjustment for the characteristics mentioned above.

Second, we performed logistic-regression analysis to assess whether the availability of electronic health records was associated with a report by respondents that an electronic-records system had a positive effect on certain aspects of their practice. The third analysis assessed whether physicians were satisfied with their electronic records. The fourth analysis examined the barriers to and facilitators of adoption. These analyses were restricted to physicians who reported having access to a basic system or a fully functional system; the analyses were adjusted for significant characteristics of physicians and their practices.

Table 2. Characteristics of Survey Respondents and Their Practices.*

Characteristic	Respondents (N=2607)	AMA Characteristics (N=494,742)	P Value
	no. (%)		
Physician			
Sex			<0.001
Male	1963 (75)	355,747 (72)	
Female	642 (25)	138,492 (28)	
Missing data	2 (<1)	503 (<1)	
Race or ethnic group†			
Hispanic or Latino			
Yes	124 (5)	NA	
No	2332 (89)	NA	
Missing data	151 (6)	NA	
White	2014 (77)	NA	
Black	95 (4)	NA	
Asian	385 (15)	NA	
Other	35 (1)	NA	
Physician specialty			0.33
Primary care	1231 (47)	238,315 (48)	
Not primary care	1376 (53)	256,427 (52)	
Practice			
No. of years since graduation			<0.09
1–9	300 (12)	50,407 (10)	
10–19	772 (30)	147,032 (30)	
20–29	780 (30)	146,385 (30)	
≥30	755 (29)	150,917 (31)	
Missing data	0	1 (<1)	
No. of physicians in practice			
1–3	1155 (44)	NA	
4–5	456 (17)	NA	
6–10	444 (17)	NA	
11–50	342 (13)	NA	
>50	105 (4)	NA	
Missing data	105 (4)	NA	
Clinical setting			
Hospital or medical center	834 (32)	NA	
Office not attached to a hospital or medical center	1639 (63)	NA	
Other	81 (3)	NA	
Missing data	53 (2)	NA	
Location			
Urban	2158 (83)	NA	
Rural	449 (17)	NA	
Region			
Northeast	508 (19)	NA	
Midwest	602 (23)	NA	
South	895 (34)	NA	
West	602 (23)	NA	

* The characteristics of respondents were compared with those in the 2007 Physician Masterfile of the American Medical Association (AMA) with the use of two-tailed chi-square tests. The total number of respondents does not include 151 who provided incomplete responses. Percentages may not total 100 because of rounding. NA denotes not available.
† Respondents could select more than one race or ethnic group.

RESULTS

SURVEY RESPONDENTS

Four percent of respondents reported having a fully functional electronic-records system, and 13% reported having a basic system. Of the small number of respondents who had a fully functional system, 71% reported that their system was integrated with the electronic system at the hospital where they admit patients, as compared with only 56% of respondents with a basic system ($P=0.006$).

Among the 83% of respondents who did not have electronic health records, 16% reported that their practice had purchased but not yet implemented such a system at the time of the survey. An additional 26% of respondents said that their practice intended to purchase an electronic-records system within the next 2 years.

FACTORS ASSOCIATED WITH AVAILABILITY

In multivariate analyses, having an electronic-records system was significantly associated with several characteristics of both individual physicians and their practices (Table 3). Electronic-records systems were more prevalent among physicians who were younger, worked in large or primary care practices, worked in hospitals or medical centers, and lived in the western region of the United States. Rates of adoption did not differ significantly among providers serving a high proportion of minority patients or patients who were uninsured or receiving Medicaid, as compared with other physicians (data not shown).

FREQUENCY OF USE

Among the 4% of doctors with a fully functional electronic-records system, 97% reported using all the functions at least some of the time. Among the 13% of doctors with a basic system, more than 99% reported using all the functions at least some of the time.

OTHER CAPABILITIES

Physicians with electronic health records were asked to report the extent to which these systems allowed patients to do each of the following online: view and make changes to their medical records and request prescription refills, appointments, and referrals. Physicians with fully functional electronic-records systems were significantly more likely than those with basic systems to have each of these functions (Table 4). Enabling patients to request a prescription refill online was a prevalent function for both basic systems and fully functional systems.

EFFECT ON PRACTICES

Figure 1 shows the percentages of respondents reporting positive effects of electronic health records on various aspects of their practices. Among the small number of respondents who had fully functional electronic-records systems, most physicians reported the positive effects of the system on the quality of clinical decisions (82%), communication with other providers (92%) and patients (72%), prescription refills (95%), timely access to medical records (97%), and avoidance of medication errors (86%). Furthermore, 82 to 85% reported a positive effect on the delivery of long-term and preventive care that meets guidelines. For physicians with basic systems, the magnitudes of effects were generally smaller. Results were adjusted for the characteristics of physicians and their practices.

Respondents also reported on whether the use of electronic health records had assisted in the care of patients in several specific ways (Table 4). Most of those with fully functional systems reported averting a known drug allergic reaction (80%) or a potentially dangerous drug interaction (71%), being alerted to a critical laboratory value (90%), ordering a critical laboratory test (68%), and providing preventive care (69%). Physicians with basic electronic-records systems reported having the same effects but less commonly than did those with fully functional systems.

PHYSICIAN SATISFACTION

A large majority of physicians reported being satisfied with their electronic-records systems overall (93% for fully functional systems and 88% for basic systems, $P=0.20$) and with the ease of use of the system when providing care to patients (88% and 81%, respectively; $P=0.11$). Physicians with fully functional electronic-records systems were significantly more likely to be satisfied with the reliability of their system than were those with basic systems (90% and 79%, respectively; $P=0.01$). Here again, results were adjusted for the characteristics of physicians and their practices.

BARRIERS TO ADOPTION

Among physicians who did not have access to an electronic-records system, the most commonly cited barriers to adoption were capital costs

Table 3. Rates of Adoption of Electronic Health Records by Physicians, with Adjustment for the Characteristics of the Physicians and Their Practices.*

Variable	Fully Functional System (N=117)	Standard Error	Basic System (N=330)	Standard Error	No Basic or Fully Functional System (N=2160)	Standard Error	P Value
				percent			
All physicians	4	1	13	1	83	<1	
Sex							0.76
Male	4	1	13	1	83	1	
Female	4	1	13	1	83	2	
Race or ethnic group†							0.99
Hispanic or Latino	4	1	13	2	83	3	
White	4	1	13	1	82	1	0.84
Black	5	2	14	4	80	6	0.72
Asian	5	2	14	3	82	5	0.82
Other	3	2	10	4	87	6	0.45
Medical specialty							<0.001
Primary care	6	1	15	1	80	1	
Not primary care	4	<1	11	1	86	1	
No. of years in practice							0.009
1–9	5	1	15	2	80	2	
10–19	5	1	14	1	81	1	
20–29	5	1	14	1	82	1	
≥30	3	1	10	1	87	1	
No. of physicians in practice							<0.001
1–3	2	<1	7	1	91	1	
4–5	3	1	11	1	86	2	
6–10	6	1	17	2	77	2	
11–50	8	1	22	2	71	3	
>50	17	3	33	3	50	5	
Clinical setting							0.008
Hospital or medical center	5	1	15	1	80	1	
Office not attached to a hospital or medical center	4	<1	12	1	85	1	
Other	4	1	13	3	83	4	
Location							0.92
Urban	4	<1	13	1	83	1	
Rural	4	1	13	1	83	2	
Region							0.002
Northeast	4	1	11	1	86	2	
Midwest	4	1	13	1	83	2	
South	4	1	12	1	84	1	
West	6	1	16	1	78	2	

* Percentages were calculated with the use of multivariable analysis, applying a cumulative logit model to predict the adoption of an electronic-records system, with adjustment for all variables listed in the table. The analysis was adjusted for nonresponse. The total number of respondents does not include 151 who provided incomplete responses. Percentages (which sum across rows) may not total 100 because of rounding.
† Respondents could select more than one race or ethnic group.

Table 4. Rates of Response Regarding Functions of Electronic Health Records and Their Effects.*

Survey Response	Fully Functional System	Basic System	P Value
	percent		
Does your system allow patients to do the following?			
View their medical records online	50	24	<0.001
Make changes to or update their medical records online	26	15	0.01
Request appointments online	52	26	<0.001
Request referrals online	36	14	<0.001
Request refills for prescriptions online	63	26	<0.001
Has a prompt from the electronic-records system ever helped you do the following?			
Prevent a drug allergy	80	66	0.01
Prevent a potentially dangerous medication interaction	71	54	0.002
Be alerted to a critical laboratory value	90	75	0.004
Provide preventive care	69	41	<0.001
Order a critical laboratory test	68	36	<0.001
Order a genetic test	17	8	0.03

* Percentages were calculated with the use of a multivariable logistic-regression model. Variables included in the model were medical specialty (primary care vs. not primary care), the number of years since graduation (1 to 9, 10 to 19, 20 to 29, or ≥30), the number of physicians in the practice (1 to 3, 4 to 5, 6 to 10, 11 to 50, or >50), clinical setting (hospital, private office, or other), and region (Northeast, Midwest, South, or West). Separate models were fitted for each of these questions.

(66%), not finding a system that met their needs (54%), uncertainty about their return on the investment (50%), and concern that a system would become obsolete (44%) (Table 5). Physicians with electronic health records tended to highlight the same barriers but less frequently than did nonadopters.

FACILITATORS OF ADOPTION

Among all respondents, the factors that were most frequently cited as facilitators of adoption were financial incentives for the purchase (55% among physicians with no electronic health records and 46% among those with electronic health records, P=0.001) and payment for use of an electronic-records system (57% and 52%, respectively; P=0.04). About 40% of respondents with and without an electronic-records system also reported that protecting physicians from personal liability for record tampering by external parties could be a major facilitator of adoption.

DISCUSSION

On the basis of a large, representative sample of U.S. physicians and clearly specified, replicable definitions of electronic-records systems that were developed by a panel of experts, our study indicates that electronic health records are available in the office setting to only a small minority (17%) of U.S. physicians at present. Only 4% of physicians have what the expert panel considered a fully functional electronic-records system.

Previous studies have shown that the practice setting (and especially the size of the group) had a significant influence on the adoption of electronic health records in the United States, findings that our results confirm.[5,6,11] After adjustment for other characteristics of physicians and their practices, we found that physicians who practice in groups of more than 50 were three times as likely to have a basic electronic-records system and more than four times as likely to have a fully functional electronic-records system as were physicians in groups of 3 or fewer. However, even in large groups, only a small minority (17%) had a fully functional system, and 49% had no electronic-records system at all.

Subjective reports by respondents about the influence of electronic health records on the quality of their practice and clinical decisions and about their satisfaction with the system are

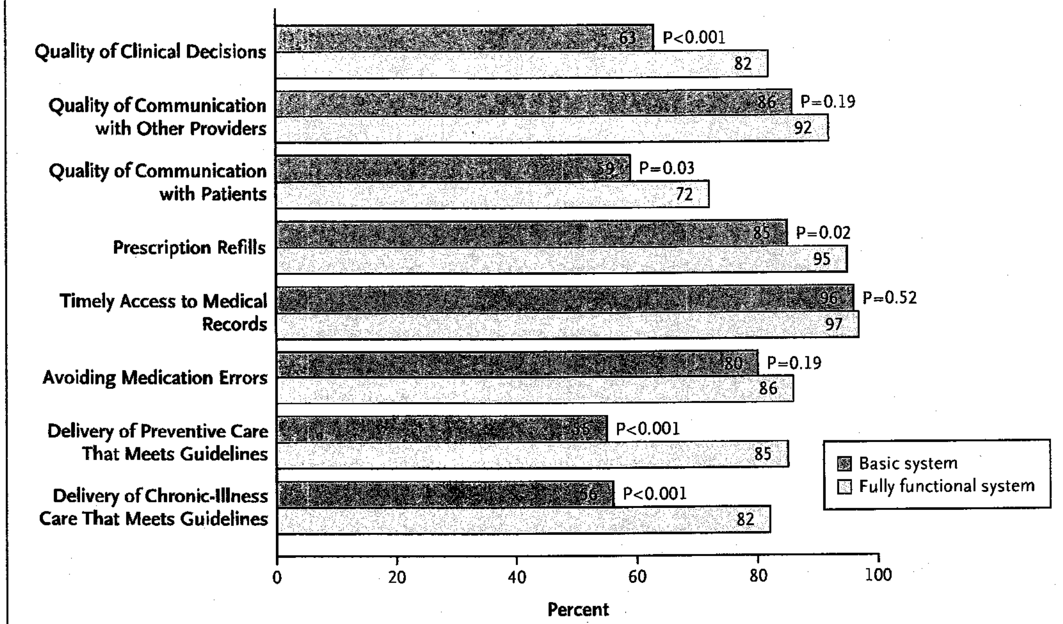

Figure 1. Rates of Positive Survey Responses on the Effect of Adoption of Electronic-Health-Records Systems.
Percentages were calculated with the use of a multivariable logistic-regression model. Variables included were medical specialty, the number of years since graduation, the number of physicians in the practice, clinical setting, and geographic region.

encouraging. The proportion of respondents reporting positive effects was generally larger for fully functional systems than for basic systems, a finding that is consistent with the hypothesis that more capable systems offer greater benefits. However, the possibility of bias among respondents, especially greater receptivity to and facility with electronic health records among early adopters, cannot be excluded. The quality and cost effects of electronic health records need to be confirmed by direct studies of clinical outcomes. Considerable controversy continues about the overall effect of electronic health records, and further research needs to clarify the effects of this technology on our health care system.[1]

It is also encouraging that a large majority of respondents reported overall satisfaction with their electronic-records system. However, approximately 20% of physicians with basic systems expressed reservations about the ease of use and reliability of their systems. Improving the usability of electronic health records may be critical to the continued successful diffusion of the technology.

Even though we used definitions and methods that differed from those used in previous studies of electronic-records systems, it is possible, within limits, to compare our findings with those of other studies. For example, in 2006, the National Ambulatory Medical Care Survey (NAMCS) showed that 9.3% of respondents had adopted systems similar to (though not exactly the same as) our current definition of a basic electronic record.[2] Applying the NAMCS definition, we found that 14% of our respondents reported having an electronic-records system. This finding suggests that the number of physicians with some type of electronic-records system has increased in the past year. The function-based approach that we used to measure the availability and use of electronic health records will enable future researchers to gauge progress in the adoption of such systems on the basis of alternative definitions, including that used by NAMCS.

Our study and others[1-3] serve to underscore both the potential benefits of electronic health records and the low current availability of this technology. The combination of these findings suggests that the U.S. health care system faces major challenges in taking full advantage of electronic health records to realize its health care goals. President Bush has proposed that elec-

Table 5. Barriers to the Adoption of Electronic Health Records.*

Variable	Any Electronic-Records System†	No Electronic-Records System	P Value
	percent		
Amount of capital needed			
Major barrier	47	66	<0.001
Minor barrier	30	22	
Uncertainty about return on investment			
Major barrier	33	50	<0.001
Minor barrier	34	31	
Resistance from physicians			
Major barrier	27	29	0.37
Minor barrier	42	42	
Capacity to select, contract, install, and implement			
Major barrier	26	39	<0.001
Minor barrier	45	42	
Concern about loss of productivity during transition			
Major barrier	35	41	0.02
Minor barrier	42	40	
Concern about inappropriate disclosure of patient information			
Major barrier	14	17	0.09
Minor barrier	43	45	
Concern about illegal record tampering			
Major barrier	14	18	0.007
Minor barrier	42	46	
Concern about the legality of accepting electronic records from hospital			
Major barrier	7	11	0.001
Minor barrier	27	33	
Concern about physicians' legal liability			
Major barrier	11	14	0.02
Minor barrier	34	38	
Finding an electronic-records system to meet needs			
Major barrier	38	54	<0.001
Minor barrier	38	32	
Concern that system will become obsolete			
Major barrier	27	44	<0.001
Minor barrier	44	40	

* Percentages were calculated with the use of a multivariable logistic-regression model. Variables included in the model were medical specialty (primary care vs. not primary care), the number of years since graduation (1 to 9, 10 to 19, 20 to 29, or ≥30), the number of physicians in the practice (1 to 3, 4 to 5, 6 to 10, 11 to 50, or >50), clinical setting (hospital, private office, or other), and region (Northeast, Midwest, South, or West). Separate models were fitted for each of these questions.

† The category includes both fully functional and basic electronic health records.

tronic health records should be widespread in the U.S. health care system by 2014, and both of the likely presidential candidates have prominently featured the diffusion of electronic health records in their health care proposals.[12-14] Indeed, recent Medicare cost-containment proposals included incentives for the adoption of health-information technology by physicians as a means of spurring greater use.[15] Our data suggest that such incentives could be important facilitators of adoption. However, the cost of achieving widespread adoption of electronic health records in the United States could be high, probably in the tens or hundreds of billions of dollars,[1,16-19] and whether any future federal administration will find the necessary resources is uncertain.

In their efforts to spur adoption of electronic health records, policymakers may benefit from studying the experience of other Western countries, which seem to have been much more successful (despite significantly lower overall national health expenditures) at encouraging the adoption of health-information technology by physicians. Data from 10 Western industrialized nations suggest that a large majority (often more than 90%) of primary care physicians currently use computers in their office practices.[20] These countries seem to have achieved these results using a variety of interventions — public and private, economic and noneconomic — that may offer guidance to future actions in the United States.[20]

Certain limitations of our study should be taken into account. Like all surveys, ours was subject to potential problems of response bias. It is possible that physicians who responded to our survey had a greater interest than did nonresponders in the subject of electronic health records. Although we adjusted for potential nonresponse bias, our data may overestimate actual rates of adoption of electronic health records. Another reason to be cautious about the reports is that the estimates of the effect of these systems on quality of care and satisfaction are based on a small number of respondents with a large margin of error, especially for the fully functional electronic-records systems. As already noted, by virtue of having electronic health records at this stage in their diffusion, the respondents with these systems are probably different from respondents without them. This limitation, coupled with the small number of adopters in our study, suggests that any extrapolation of the benefits and satisfaction with electronic health records reported by respondents should be done with caution.

In discussions about health-information technology, our study informs the debate by providing benchmark information about the levels of adoption of electronic health records by U.S. physicians as of late 2007 and early 2008. Further studies that use clear, similar definitions of electronic health records and representative samples of physicians will be necessary to inform the development of policies with regard to electronic health records in our health care system.

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Electronic Health Records: Improving Patient Safety and Quality of Care in Texas Acute Care Hospitals

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ABSTRACT

Electronic health records (EHRs) have been proposed as a sustainable solution for improving quality of medical care. This study investigates how EHR use, as implemented and utilized, impacts patient safety and quality performance. Data include nonfederal acute care hospitals in the state of Texas. Sources of data include the American Hospital Association, the Dallas Fort Worth Hospital Council, and the American Hospital Directory. The authors use partial least squares modeling to assess the relationship between hospital EHR use, patient safety, and quality of care. Patient safety is measured using 11 indicators as identified by the Agency for Healthcare Research and Quality (AHRQ) and quality performance is measured by 11 mortality indicators as related to 2 constructs: conditions and surgical procedures. Results identify positive significant relationships between EHR use, patient safety, and quality of care with respect to procedures. The authors conclude that there is sufficient evidence of the relationship between hospital EHR use and patient safety, and that sufficient evidence exists for the support of EHR use with hospital surgical procedures.

Keywords: Healthcare informatics, quality, electronic healthcare records, patient safety, partial least squares

1. INTRODUCTION

Hospitals invest in information technology to lower costs and to improve quality of care. However, it is unclear whether these expectations for information technology are being met. Current literature asserts the imperative need to improve quality of care and patient safety in the United States (Kohn et al. 2000; Bloom 2002; Case et al. 2002a). The death toll of patients due to preventable medical errors ranks as the sixth leading cause of death in America with approximately 100,000 patients dying each year (Kohn et al. 2000; Zhan and Miller 2003). This puts the mortality rate due to medical errors ahead of diabetes, liver disease and pneumonia. Additionally, there are 1.4 million hospitalizations a year that result in a medication-related injury (Kohn et al. 2000; Case et al. 2002b). Several studies have recognized the tremendous room for growth in the use of health information technology (HIT) to enhance patient care quality and safety (Ammenwerth et al. 2002; Bates 2002; Brooks et al. 2005; Plebani 2007). Specifically, the availability of information technology (IT) applications in hospitals has been identified as a means of improving patient safety and reducing the number of adverse events (Birkmeyer et al. 2000; Gaba 2000; Institute of Medicine 2001; Remus and Fraser 2004). In particular, electronic health records (EHR) have been touted as having significant benefits, such as productivity and efficiency gains, and the ability to improve patient safety and quality of care (Baron 2007; Connors 2007; Berk et al. 2008; Crane and Crane 2008; Eden et al. 2008; Ketchum 2008; Smith and Kalra 2008).

In that spirit, our study investigates the impact of EHR usage and utilization on quality performance and patient safety. There is currently an absence of empirical evidence showing EHRs impact on quality performance and patient safety. In addition, the findings of this research inform healthcare administrators about the return of usage and utilization of costly HIT investments. Finally, provisions on the subsidies provided by government for capital investments can be influenced by the impact of EHR usage on healthcare quality.

2. EHRs IN HEALTHCARE

Electronic health records are defined as a longitudinal collection of electronic health information about individual patients and populations. It is 'a mechanism for integrating health care information currently collected in both paper and electronic medical records (EMR) for the purpose of improving quality of care' (Gunter and Terry 2005). This may include information regarding a patient's medical history of illnesses, digital radiology images, list of allergies, billing records, etc. Keeping medical records electronically has noted advantages over paper records, such as increased accuracy, decreased medical errors (e.g. diagnosis and prescription related fatal errors) and mortality rates, improved efficiency and productivity, lowered costs and better, safer, more equitable care (Baron et al. 2005; Basch 2005; Leipold 2007). The anticipated benefits of EHR are so vast that policy makers have called for universal EHR adoption by 2014, and current scholarly literature has given much attention to the potential improvements in quality of care by EHR implementation. Studies have predicted that EHR will help in the reduction of medication errors (Shortliffe 1999; Thompson and Brailer 2004; Linder et al. 2007) and in the improvement of quality of health care services (Miller and Sim 2004; Fonkych and Taylor 2005).

While literature recognizes the potential life-saving benefits of EHR in healthcare, their actual impact on and relationship to patient outcomes is still unclear. The majority of EHR literature available takes a management perspective and concentrates mainly on adoption, implementation, acceptance and barriers (Overhage et al. 2001; Ash and Bates 2004; Miller and Sim 2004; Chiang et al. 2008; Withrow 2008; Zandieh et al. 2008). However, research that examines the actual impact that EHRs have in the healthcare system is sparse. While some previous research examined the relationship between EHRs and quality (Spencer et al. 1999; Kinn et al. 2001; Asch et al. 2004; Linder et al. 2007; Kazley and Ozcan 2008), the most common examples of empirical analysis have been case studies that examine specialized sample populations of healthcare (i.e. VHA, ambulatory, labor and delivery, etc.), or utilize small sample sizes and qualitative evidence with limited generalizability (Kinn et al. 2001; Asch et al. 2004;

Miller et al. 2005; DesRoches et al. 2008; Eden et al. 2008; Edwards et al. 2008; Smith and Kalra 2008). Furthermore, the outcomes of interest vary using limited measures of quality (i.e. medication error rate, adherence to protocol, specified illnesses).

This study progresses research by expanding EHR investigation to include operational outcomes of acute care hospitals. A conceptual model showing the relationships between the constructs used and other components is given in Figure 1. Specifically, the inclusion of quality and patient safety metrics that have been developed and validated by the Agency for Healthcare Research and Quality (AHRQ) and utilized in previous healthcare research will broaden the scope of knowledge. These measures will allow us to answer the question, "Can EHRs increase quality and patient safety in acute care hospitals?" Additionally, we advance current research by introducing physician usage into the EHR variable and by analyzing hospital EHRs that have been categorized into four functional groups: patient information data, results management, order entry and decision support. To date, studies have focused on the availability of EHRs, with limited attention towards the varying functions within an EHR or the degree to which doctors are utilizing those functionalities (Simon et al. 2008). However, the absence of both have been noted limitations of relevant literature (Linder et al. 2007; Kazley and Ozcan 2008).

3. THEORETICAL FRAMEWORK

Some previous research has examined the relationship between EHR implementation and quality. Asch et al. 2004 studied the quality of care for patients at the Veteran's Health Adminitration (VHA) and found the VHAs EHR system to be associated with higher levels of patient care quality. Also contributing to quality, Spencer et al 1999 reported that EHRs combined with continuous quality improvement lead to drastic improvements in documentation and screening at a clinic in Eau Claire, Wisconsin.

EHRs are predicted to make the process of health care more standardized and automated through the presence of screen prompters, mandatory patient information fields to be entered, and tools to catch prescription interactions or inappropriate diagnoses (Shortliffe 1999; Miller and Sim 2004). These improved automated processes are expected to lead to fewer medical errors and oversights, thus improving health care quality performance and patient safety. Proponents of EHRs claim that they will reduce medical errors by ensuring that physicians follow protocol and through the decrease of adverse prescription use based on an automated interaction detection and through automated access physicians may have to patient laboratory and other diagnostic results (Medicine 2001; Ash and Bates 2004; Thompson and Brailer 2004). Further, EHRs will eliminate mistakes that occur based on illegible handwritten medical records. EHRs allow providers immediate access to patient information, are connected to a library of medical information, and often generate reminders or indications of important or time-sensitive clinical information (Miller and Sim 2004; Thompson and Brailer 2004; Linder et al. 2007). These EHR systems also enable clinicians within the same facility to access and edit medical records for a patient immediately instead of having to wait for a paper record; thus, changing provider communication and coordination of care for teams of physicians (Kazley and Ozcan 2008).

It is through these changes in the process of care achieved by utilizing EHRs that we will see improved health care quality performance and increased patient safety. Therefore, we hypothesize that:

H1: EHR implementation and usage in hospitals improves the mortality rates based on common medical conditions.

H2: EHR implementation and usage in hospitals decreases the mortality rates based on surgical procedures.

H3: EHR implementation and usage in hospitals will enhance patient safety.

4. CONSTRUCT DEVELOPMENT

4.1 Electronic Health Records

Electronic Health Records (EHR) is operationalized in this study using data collected from the American Healthcare Association's annual survey. Hospitals were surveyed regarding the presence of an EHR and the implementation status of the EHR (fully or partially implemented). Further, EHRs were dissected into four categories: Patient-level information data, Results management, Order entry management, and Decision support. Hospitals Information pertaining to the implementation of each category of EHR was then assessed as fully implemented, partially implemented, or not implemented. Finally, the percentage of treating physicians in each hospital that routinely orders medications and laboratory/other tests electronically were assessed (Table 1).

4.2 Quality and Patient Safety

For purposes of this research the Agency for Healthcare Research and Quality (AHRQ) Inpatient Quality Indicators (IQIs) and Patient Safety Indicators (PSIs) were adopted to operationalize the constructs *Quality* and *Patient Safety*. The IQIs focus on the health care provided within an inpatient hospital setting and the mortality rates provided are a proxy measure of *Quality*. PSIs are a set of measures that can be used to screen for adverse events and complications that patients may experience as a result of exposure to the health care system. The PSIs provide a measure of the potentially preventable complication for patients who received their initial care and the complication of care within the same hospitalization. Provider-level indicators are included in this study and report only those cases where a secondary diagnosis code flags a potentially preventable complication. Scientific evidence for these indicators is based on reports in peer reviewed literature. Structured literature review and empirical analyses were used to establish validity of the indicators and details regarding the development process are presented in the publication "Refinement of the HCUP Quality Indicators" available at www.qualityindicators.ahrq.gov (AHRQ 2003).

Eleven mortality measures are utilized to examine quality of healthcare. These measures evaluate outcomes following procedures and for common medical conditions. The mortality indicators are divided into two quality constructs for analysis: procedures and conditions. All mortality measures are reported as part of this research, with the exception of carotid endarterectomy, hip fracture, and hip replacement because of the low volume of such procedures performed in our sample from the state of Texas, due to the limitation they introduce ….(why are they excluded?) (if this was driven with the data analysis, maybe putting this in the discussion section as a limitation would be better. What do you think?). The safety construct is comprised of eleven safety indicator rates. Indicators that were coded as rare, under-reported, unscreened, or obstetrical were excluded from the model as recommended by AHRQ due to possible skewing of the data. Table 2 displays the comprised indicators for each construct.

All employed IQI and PSI measures in this study, with the exception of Death in Low Mortality diagnostic related groups (DRGs), are risk-adjusted rates that reflect the age, sex, modified DRGs, and comorbidity distribution of data in the baseline file, rather than the distribution for each hospital. The use of risk-adjusted rates facilitates the ability to generalize the data and puts each hospital "on an even playing field." The observed rate for Death in Low Mortality DRGs is measured due to the risk-adjustment transforming all hospital rates to zero.

5. DATA ANALYSIS AND METHODOLOGY

The primary analysis of the relationship between EHR implementation, quality, and safety was performed using secondary data collected and compiled from three data sources. The American Hospital Association's (AHA) annual hospital survey provided information pertaining to EHR implementation, type of EHR function employed, and physician usage of EHR. The DFWHC database supplied inpatient quality indicators (IQI) and patient safety indicators (PSI) that were developed by the Agency for Healthcare Research and Quality (AHRQ). Finally, the American Hospital Directory (AHD) provided key hospital characteristics and demographic data.

In order to combine datasets, the AHA survey data of 577 Texas hospitals was reviewed. Records with incomplete or missing data were removed and EHR information was gathered for the remaining 364 hospitals. Second, demographics, IQIs, and PSIs for the Texas hospitals were extracted from their appropriate databases. The hospitals from both databases were then relationally joined to the sample from AHA and a new sample dataset was formed. All hospital information, including names, IDs, and addresses, were evaluated to ensure accuracy in the merging of datasets. Any hospital not appearing in all three data files or who could not be confidently identified as matches were deleted from the sample. Upon completion of merging and cleaning of the datasets, the sample included 253 Texas acute care hospitals.

Initial partitioning of the data revealed a significant amount of variation between public/private hospitals and government owned hospitals. Since the number of government hospitals was relatively small (44), we deleted these hospitals from the sample and no analyses were performed on them. The final sample utilized in this study was comprised of 209 Texas acute care hospitals.

5.1 Data Analysis

Analysis was performed using Partial Least Squares (PLS) modeling. PLS is a structural equation modeling (SEM) technique that assesses the psychometric properties of the scales employed to measure the theoretical constructs and estimates the hypothesized relationships among said constructs. While other SEM tools exist, the choice to use PLS was driven by several factors including PLS' ability to handle both formative and reflective indicators, it's suitability for prediction and the exploration of *plausible causality,* the lack of multivariate normality assumption, and PLS's lower sample size requirements (Chin et al. 2003 ; Westland 2007).

5.2 Measurement Model

In order to explore the construct dimensions and validate the indicators as the proxies for quality and patient safety, an Exploratory Factor Analysis was run using the Principal Components extraction method with Varimax rotation. The indicators used are all validated with each indicator having factor loading value >0.40. The results from the Exploratory Factor Analysis confirmed the need to remove post-operative derangement from the Safety factor, and hip fracture, hip replacement, and carotid endarterectomy from the Quality construct. All other items loaded as predicted onto their dimensions (Table 3).

In order to test the validity and reliability of the constructs, the Rossiter (2002) procedure for scale development was followed. First, convergent and discriminate validity were determined. All factor loadings were greater than the 0.40 cutoff, with most loadings exceeding .60 (Nunnally 1967). The high factor loadings give reason to conclude that the measures have convergent validity. Discriminant validity was evaluated using the average variance extracted (AVE) calculated by the SmartPLS software. All constructs exceeded the .50 cutoff recommended by Fornell and Larcker (1981) with the exception of conditions (AVE=.4677) and safety (AVE=.4689). However, these dimensions were found to have adequate convergent validity based on their high factor loadings (>.50) (Gerbing and Andersen 1988; Das et al. 2000), and the average variance extracted for each latent factor exceeded the respective squared correlation between factors (Fornell and Larcker 1981). Finally, reliability of the scale items were evaluated and all values fell within the acceptable range to conclude good reliability (Nunnally 1967; Van de Venn and Ferry 1980; Srinivasan 1985). Validation and reliability results can be seen in table 4. The results indicate that all the indicators used as proxies of quality and safety are valid and reliable measures.

5.3 Structural Model and Hypotheses Test

The results of the overall structural model with all hypothesized paths revealed a model with adequate fit. The criterion put forth by Rossiter (2002) states that for the structural model all paths should result in a t-value greater than 2 and latent variable R-Squares (R^2) greater than 50%. SmartPLS calculated the R-Square and t-values for the full structural model and all path t-values met the required cut off with the exception of EHR→ conditions (t-value = 1.439). As the predicted paths for the structural model are all hypothesized unidirectional relationships, all t-values, with the exception of conditions, well surpass the t-critical value of 1.645 at a 0.05 level of significance. Additionally, all R-Square values exceed the 50% threshold and therefore, adequate fit is concluded. Table 5 presents the path coefficient means, standard deviations, and t-values.

6. RESULTS AND DISCUSSION

The evaluation criterion for testing each hypothesis was the use of t-values for each path loading. Significant t-values for path loadings signify support for the proposed hypothesis. The cutoff criteria used was a t-value greater or equal to 1.645 for an alpha level of .05 (Hair et al. 2006). All proposed hypotheses were supported with the exception of the relationship between EHRs and conditions. However, the lack of relationship between EHR usage and the construct conditions is not totally surprising. Previous research has similarly shown little link between EHR implementation and a reduction in mortality for those patients suffering from designated clinical conditions (Linder et al. 2007; Kazley and Ozcan 2008; Zhou et al. 2009).

This study, however, advances research by looking at the mortality indicators for quality as divided into two separate constructs: surgical procedures and conditions. By dissecting the mortality indicators we are able to observe the significant positive relationship between EHRs and surgical procedures that has previously been undistinguishable. Further, this paper takes a distinct approach in evaluating hospital EHR implementation and usage that to our knowledge has not previously been utilized. By denoting the type of function available in the EHR system (decision support, order entry, results management, and patient-level data) and the degree of the function's implementation, we are able to better capture a more complete representation of the hospital EHR. In addition, the introduction of actual physician utilization of the EHR system to electronically order medications and laboratory/other tests provides an enhanced picture that prior research has yet to offer.

With the amount of money spent each year on IT, it is critical to understand what role these advancements play within the operational aspects of our healthcare system. The studies presented provide a starting point into investigations of information technology in healthcare, specifically in the domain of electronic health records. The question was posed as to whether or not EHRs can facilitate an environment in which hospitals can provide higher quality of care and at the same time improve patient safety. The answer based on the research presented is yes; the use of EHRs has the potential to decrease mortality rates while significantly improving patient safety. These findings support that electronic health record systems are much more than record keeping devices. They include numerous features that have the potential to vastly improve health care outcomes. They provide physicians with preventive care reminders, allergy alerts, suggestions for diagnostic or treatment options, links to medical literature, computerized physician order entry, and data analysis tools that reduce medical errors and improve patient safety and quality of care.

The recent environment for health care organizations has focused attention on providing high quality of care at a containable cost. While the adoption of EHRs promises to improve clinical outcomes and increase patient safety, it is important to note that EHR systems are comprised of several functionalities that must be used in an integrated manner in order to realize their full potential (Menachemi et al. 2007). As seen in this study, it is possible to partially adopt an EHR by using only selected functionalities of the system. This, coupled with the fact that not all treating physicians in a hospital utilize an available EHR system, gives us some insight into why not all EHR adopters realize the hoped-for gains in clinical outcomes and patient safety. Therefore, measuring EHR implementation, degree of functionality adoption, and physician usage are essential in achieving the results of increased quality of care and patient safety.

TABLES AND FIGURES

Table 1 % Physicians Ordering Electronically

Medications	Frequency	Percent	**Lab & Other Tests**	Frequency	Percent
0%	171	82.2		160	76.9
1-24%	20	9.6		26	12.5
25-49%	4	1.9		3	1.4
50-74%	4	1.9		5	2.4
75-100%	9	4.3		14	6.7
Total	208	100.0		208	100.0

Table 2 AHRQ Indicators included for *Quality* and *Patient Safety* constructs

IQI	Procedures	PSI	Patient Safety
6	Percutaneous Transluminal Coronary Angioplasty Volume	1	Complications of Anesthesia
9	Pancreatic Resection	3	Decubitus Ulcer
11	Abdominal Aortic Aneurysm Repair Mortality Rate	6	Iatrogenic pneumothorax
12	Coronary Artery Bypass Graft Mortality Rate	7	Selected Infections Due to Medical Care
13	Craniotomy Mortality Rate	8	Postoperative Hip Fracture
	Conditions	9	Postoperative Hemorrhage or
15	Acute Myocardial Infarction Mortality	11	Postoperative Respiratory Failure
16	Congestive Heart Failure Mortality Rate	12	Postoperative PE or DVT
17	Acute Stroke Mortality Rate	13	Postoperative Sepsis
18	Gastrointestinal Hemorrhage Mortality Rate	14	Postoperative wound dehiscence in abdominopelvic surgical
20	Pneumonia Mortality Rate	15	Accidental puncture and laceration
32	Acute Myocardial Infarction Mortality Rate, W/O Transfer Cases		

Table 3 Study Scale Factor Loadings

Study Scale Items	Factor Loadings
Mortality	
Procedures:	
AAA Repair	0.61
CABG (Coronary Artery Bypass Graft mortality)	0.88
CRANI (Craniotomy mortality)	0.81
PANCR (Pancreatic Resection mortality)	0.42
PTCA (Percutaneous Transluminal Coronary Angioplasty mortality)	0.85
Conditions:	
AMI (Acute Myocardial Infarction mortality)	0.86
AMI wo Trans (AMI with out transfer cases mortality)	0.87
CHF (Congestive Heart Failure mortality)	0.69
GI Hem (Gastrointestinal Hemorrhage mortality)	0.52
PNEUM (Pneumonia mortality)	0.60
STROKE (Acute Stroke mortality)	0.59
Patient Safety	
HEM (Post Operative Hemorrhaging)	0.56
RESP (Post Operative Respiratory Failure)	0.76
DVT (Post Operative Deep Veing Thrombosis)	0.75
HIP (Post Operative Hip Fracture)	0.57
SEPS (Post Operative Sepsis	0.67
WND (Post Operative wound and dehiscence in abdominopelvic patients)	0.52
SEL (Selected Infections Due to Medical Care)	0.76
ACC_PUNC (Accidental Puncture and Laceration)	0.61
COMP_ANES (Complications of Anestesia)	0.46
IAT_PNEU (Iatrogenic pneumothorax)	0.75
ULCER (Decubitus Ulcer)	0.64

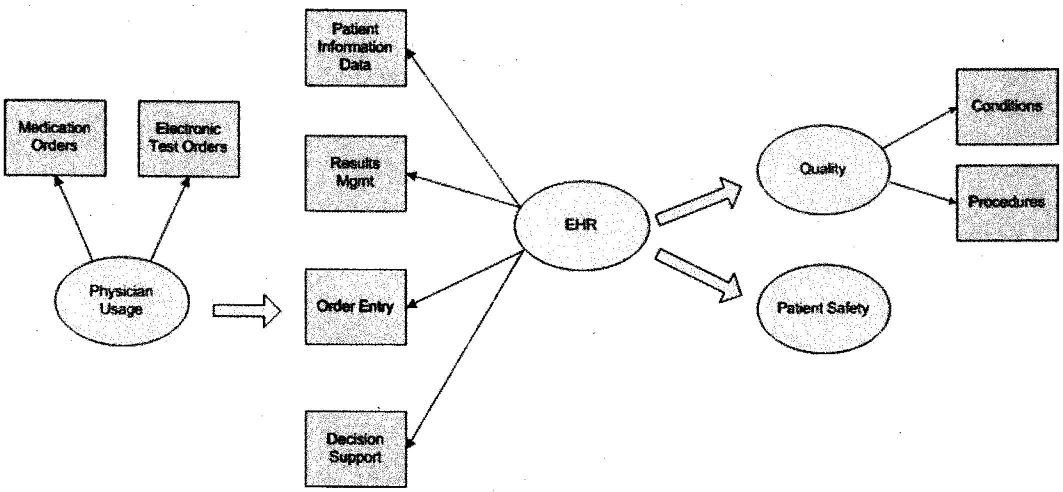
Table 4 Construct Statistics

Construct	R^2	Composite	Cronbach's	AVE	1	2	3	4
1. EHR		0.87	0.81	0.65	**.81**			
2. Procedures	0.65	0.81	0.73	0.51	.28	**.71**		
3. Conditions	0.63	0.73	0.75	0.47	.10	.38	**.69**	
4. Safety	0.50	0.85	0.83	0.46	.34	.54	.21	**.68**

Table 5 Construct Path Statistics

Path	Mean	σ	t-stat
EHR → Conditions	0.1846	0.2305	1.4389
EHR → Procedures	0.3071	0.1026	2.6782
EHR → Safety	0.3811	0.0896	3.8098

Figure 1 General Conceptual Model



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Impact of Electronic Health Record Clinical Decision Support on Diabetes Care: A Randomized Trial

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ABSTRACT

PURPOSE We wanted to assess the impact of an electronic health record–based diabetes clinical decision support system on control of hemoglobin A_{1c} (glycated hemoglobin), blood pressure, and low-density lipoprotein (LDL) cholesterol levels in adults with diabetes.

METHODS We conducted a clinic-randomized trial conducted from October 2006 to May 2007 in Minnesota. Included were 11 clinics with 41 consenting primary care physicians and the physicians' 2,556 patients with diabetes. Patients were randomized either to receive or not to receive an electronic health record (EHR)–based clinical decision support system designed to improve care for those patients whose hemoglobin A_{1c}, blood pressure, or LDL cholesterol levels were higher than goal at any office visit. Analysis used general and generalized linear mixed models with repeated time measurements to accommodate the nested data structure.

RESULTS The intervention group physicians used the EHR-based decision support system at 62.6% of all office visits made by adults with diabetes. The intervention group diabetes patients had significantly better hemoglobin A_{1c} (intervention effect −0.26%; 95% confidence interval, −0.06% to −0.47%; $P = .01$), and better maintenance of systolic blood pressure control (80.2% vs 75.1%, $P = .03$) and borderline better maintenance of diastolic blood pressure control (85.6% vs 81.7%, $P = .07$), but not improved low-density lipoprotein cholesterol levels ($P = .62$) than patients of physicians randomized to the control arm of the study. Among intervention group physicians, 94% were satisfied or very satisfied with the intervention, and moderate use of the support system persisted for more than 1 year after feedback and incentives to encourage its use were discontinued.

CONCLUSIONS EHR-based diabetes clinical decision support significantly improved glucose control and some aspects of blood pressure control in adults with type 2 diabetes.

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INTRODUCTION

Despite recent improvement trends in the United States, in 2008 less than 20% of patients with diabetes concurrently reach evidence-based goals for hemoglobin A_{1c} (glycated hemoglobin), systolic and diastolic blood pressure, and low-density lipoprotein (LDL) cholesterol levels.[1,2] Care is unsatisfactory in both subspecialty and primary care settings, but because more than 80% of diabetes care is delivered by primary care physicians, effective strategies to improve diabetes care in primary care settings are urgently needed.

Among the major barriers to better diabetes care is lack of timely intensification of pharmacotherapy in patients who have not achieved recommended clinical goals. Many factors contribute to this problem, including competing demands at the time of the visit[3] and medication

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nonadherence.[4] Rates of treatment intensification when patients are not at goal, however, hover around 70% to 80%,[5] and several studies have linked higher rates of treatment intensification by a primary care physician to better rates of hypertension, lipid, or glucose control in that primary care physician's patients.[6]

In theory, treatment intensification and control of hemoglobin A_{1c}, blood pressure, and lipid levels in patients with diabetes mellitus could be improved by providing patient-specific and drug-specific clinical decision support at the time of a clinical encounter. Electronic health records (EHRs) can be programmed to include sophisticated clinical algorithms that take advantage of current and past clinical information to provide detailed clinical recommendations at the time of a clinical encounter.[7-9] Prior efforts have typically improved processes of care (such as rate of hemoglobin A_{1c} or LDL cholesterol testing or eye examinations) but failed to improve key intermediate outcomes of care, such as control of hemoglobin A_{1c}, blood pressure, or LDL cholesterol levels.[10-16] It is especially important to improve hemoglobin A_{1c}, blood pressure, and LDL cholesterol levels, because appropriate control of these risk factors can substantially influence the rate of major microvascular or macrovascular complications of diabetes.[17-21]

Beyond diabetes care, many studies document the failure of EHR-based clinical decision support to improve key intermediate clinical outcomes in patients with hypertension, congestive heart failure care, asthma, and other conditions.[22-25] A careful reading of these failed studies, including several of our own, identified several possible reasons why EHR-based clinical decision support failed to improve intermediate outcomes of chronic disease care. First, most clinical decision support was limited to general prompts and reminders and did not include more detailed drug-specific advice. Second, introduction of EHR-based clinical decision support was usually not accompanied by changes in staff responsibilities and clinic workflow to enhance the impact of the clinical decision support on care. Third, rather than being used for visit planning, clinical decision support displays were usually provided late in the encounter and were often skipped over or not viewed by physicians. Finally, physicians typically received no tangible compensation or reward for the extra time and effort needed to adopt new and unfamiliar clinical routines.

Based on these observations, we developed, pilot tested, and refined a novel patient-customized EHR-based clinical decision support system for type 2 diabetes care designed to overcome obstacles to use observed in earlier studies. Here we report a clinic-randomized trial that assessed the impact of this EHR-based clinical decision support system on intermediate outcomes of diabetes care, including hemoglobin A_{1c}, blood pressure, and LDL cholesterol control.

METHODS

The study was reviewed in advance, approved, and monitored on an ongoing basis by the HealthPartners Institutional Review Board, project #03-083, and by an independent data safety and monitoring board.

Design Overview

This group-randomized trial tested the hypothesis that an EHR-based clinical decision support system would improve hemoglobin A_{1c}, blood pressure, and lipid control in adults with type 2 diabetes receiving care from primary care physicians.

Setting and Participants

The study was conducted at HealthPartners Medical Group (HPMG), a large medical group in Minnesota that provided care to approximately 9,000 adults with diabetes in 2007. Most diabetes care was provided by primary care physicians; 10% of type 2 patients each year see an endocrinologist, most for 1 visit.

Primary care physicians were eligible for the study if they practiced in a study clinic, provided care to at least 10 adults with type 2 diabetes, and provided written informed consent to participate. Patients were classified as having diabetes if they had 2 or more outpatient diabetes *International Classification of Diseases, Ninth Revision (ICD-9)* codes (250.xx) or used 1 or more diabetes-specific medications in the 1-year period before randomization.[26] This diabetes identification method has estimated sensitivity of 0.91 and positive predictive value of 0.94.[26]

Randomization and Interventions

Eleven HPMG clinics that used EHRs for 2 or more years were included in this study. Pairs of clinics having a similar proportion of patients at a composite diabetes care goal were placed into strata. Within each stratum a clinic was randomly assigned to either the intervention or control arm.

The EHR-based diabetes clinical decision support system (referred to as Diabetes Wizard) was provided to physicians at the 6 intervention clinics. Nursing staff and physicians participated in a 1-hour training session during which they were instructed that the Diabetes Wizard was not meant to override or supersede clinical judgment, and that its use was limited to type 2 diabetes patients aged 18 to 75 years. Adults aged 75 years and older and those with a Charlson comorbidity scores of 3 or more (indicating high short-term risk of mortality) were excluded from the study because of legitimate debate about appropriate clinical goals in such patients.[27-29]

Diabetes Wizard implementation included the following changes in clinic workflow at intervention clinics. (1) The rooming nurse enters blood pressure readings into EHR as usual. (2) If the patient has diabetes, the rooming nurse opens the Diabetes Wizard in the EHR with a single click on the navigation bar, prints the EHR-generated Diabetes Wizard form (Figure 1), and closes the form in the EHR. (3) The rooming nurse places the printed form on top of the visit summary sheet on the examination room door. (4) The physician reviews the available diabetes treatment options printed on the form just before entering the room and proceeds with the visit. (5) After the visit but before closing the encounter, the physician opens the Diabetes Wizard form in the EHR visit navigator and completes the brief visit resolution form.

Diabetes Wizard recommendations are based on detailed clinical algorithms constructed by the research team (J.S.H., P.J.O.) consistent with evidence-based diabetes guidelines from the Institute for Clinical Systems Improvement and from other evidence-based sources.[30-31] Diabetes Wizard provides recommendations in the following categories: (1) suggests specific changes in medications for patients not at individualized hemoglobin A_{1c}, blood pressure, or lipid goals; (2) suggests changes in treatment for patients with contraindications to existing treatments (eg, metformin use in renal insufficiency or congestive heart failure), or being treated with potentially risky drug combinations (eg, concomitant β-blocker and nondihydropyridine calcium channel blocker); (3) suggests obtaining overdue laboratory tests, such as for potassium, serum creatinine, creatinine kinase, or liver function tests; and (4) suggests short follow-up intervals, such as monthly visits, for patients not at goal, because more frequent visits are associated with better chronic disease outcomes in many clinical trials.

After each office visit at which the Diabetes Wizard was deployed, the physician was asked to complete a brief (15 seconds per clinical domain) visit resolution form to indicate whether treatment was intensified at the time of the visit. The fastest way to complete the visit resolution form was to intensify pharmacotherapy for patients not at goal. Lifestyle advice was also considered an intervention. If no intervention occurred, physicians were asked to specify why not.

During the 6-month intervention period, physicians and clinics received monthly summaries and feedback to encourage high rates of Diabetes Wizard use and visit resolution form completion. Compensation was provided to encourage Diabetes Wizard use. Nursing staff at each intervention clinic collectively received $500 compensation for training time and increased workload during the 6-month intervention period. Consenting intervention group physicians were compensated $800 at the start of the intervention and another $800 after 6 months if they completed visit resolution forms for at least 70% of all diabetes encounters. After 6 months both compensation and feedback stopped, but intervention physicians were encouraged to continue to use the Diabetes Wizard, and use was tracked electronically for 15 more months.

Figure 1. Example of Diabetes Wizard.

Glucose/A_{1c}

*****NOT AT GOAL*****

	Date	Goal
A_{1c}: 8.4	9/15/2007	<7%
CR: 1.3	9/15/2007	
CHF Dx: Not Identified		

Current Glucose Meds:
Glipizide 10 mg qd

TREATMENTS TO CONSIDER

- The treatment recommendations only apply to Type 2 Diabetes!
- Start metformin 500 mg po qd or bid. Increase dose by 500 mg every 1-2 weeks based on SMBGs to a max of 1000 mg po bid or to A_{1c} goal.

OR

- Start a thiazolidinedione (e.g. pioglitazone 15 mg po qd). Increase dose every 6-8 weeks to maximum 45 mg qd or to A_{1c} goal.

*****COMMENTS & ALERTS*****

Consider monthly visits until better glycemic control is achieved!

Was Glucose Treatment Modified?

Yes...Any of above	Yes...Other than Above	No

A_{1c} = glycated hemoglobin; bid = twice a day; CHF = congestive heart failure; CR = serum creatinine; Dx = diagnosis; po = orally; qd = every day; SMBG = self-monitored blood glucose.

Note: Diabetes Wizard screen shot with fictional clinical data for a hypothetical 68-year-old man on the fictional visit date of September 15, 2007. The questions at the bottom are components of the Visit Resolution Form and could be excluded from subsequent versions of Diabetes Wizard.

Outcomes and Follow-up

The principal dependent variable was the preintervention to postintervention change in hemoglobin A_{1c}, blood pressure, and LDL cholesterol levels. The baseline test value for hemoglobin A_{1c} and LDL cholesterol was the first test during the intervention (or last preintervention test if there was no intervention value). For systolic and diastolic blood pressures, the baseline was the last preintervention value. For all tests, postintervention status was based on the last postintervention test value. All hemoglobin A_{1c} assays were done at a single accredited clinical chemistry laboratory using a standard liquid chromatographic assay with a normal range of 4.5% to 6.1% and a coefficient of variation of 0.58% at a hemoglobin A_{1c} value of 8.8%.[32] LDL cholesterol values were calculated based on standard assays of total cholesterol, high-density lipoprotein (HDL) cholesterol, and 12-hour fasting triglycerides only when the triglyceride level was less than 400 mg/dL.[33] No changes in these laboratory assay methods occurred during the study period. Blood pressure was measured according to office routine by nursing staff or physicians, who were periodically trained in proper blood pressure measurement technique. The blood pressure value in the primary EHR vital signs slot was selected for analysis.

Statistical Analysis

The independent variable of major interest was an indicator variable for the study arm. The interaction of study arm with time assessed the differential impact of the intervention across study arms on prespecified outcomes of hemoglobin A_{1c}, systolic and diastolic blood pressure, and LDL cholesterol values. Because the trial was randomized at the clinic level, imbalance in patient characteristics was likely. Patient-level independent variables included age, sex, and validated indicator variables for coronary heart disease and congestive heart failure.[34]

This nested cohort pretest-posttest control group design accommodated clustering of occasion of measurement (baseline and postintervention) within patients who were nested within physicians who were nested within clinics. General and generalized linear mixed models with a repeated time measurement (baseline and postintervention) were used to analyze continuous (eg, laboratory values) and binary (eg, proportion of patients with a hemoglobin A_{1c} test) outcomes using SAS Proc Mixed and Proc Glimmix (SAS Institute, Cary, North Carolina). These models included a term for study arm, time (baseline or postintervention), a time × study arm interaction term, and random intercepts to account for multiple levels of nesting. The time × study arm interaction term tested the effect of the intervention arm over time relative to the effect of the control arm over time. The analyses on test values were also conducted predicting postintervention values from study arm, preintervention test value, and patient covariates. Because of the similarity in results from these two approaches, we report the findings from the time × study arm approach.

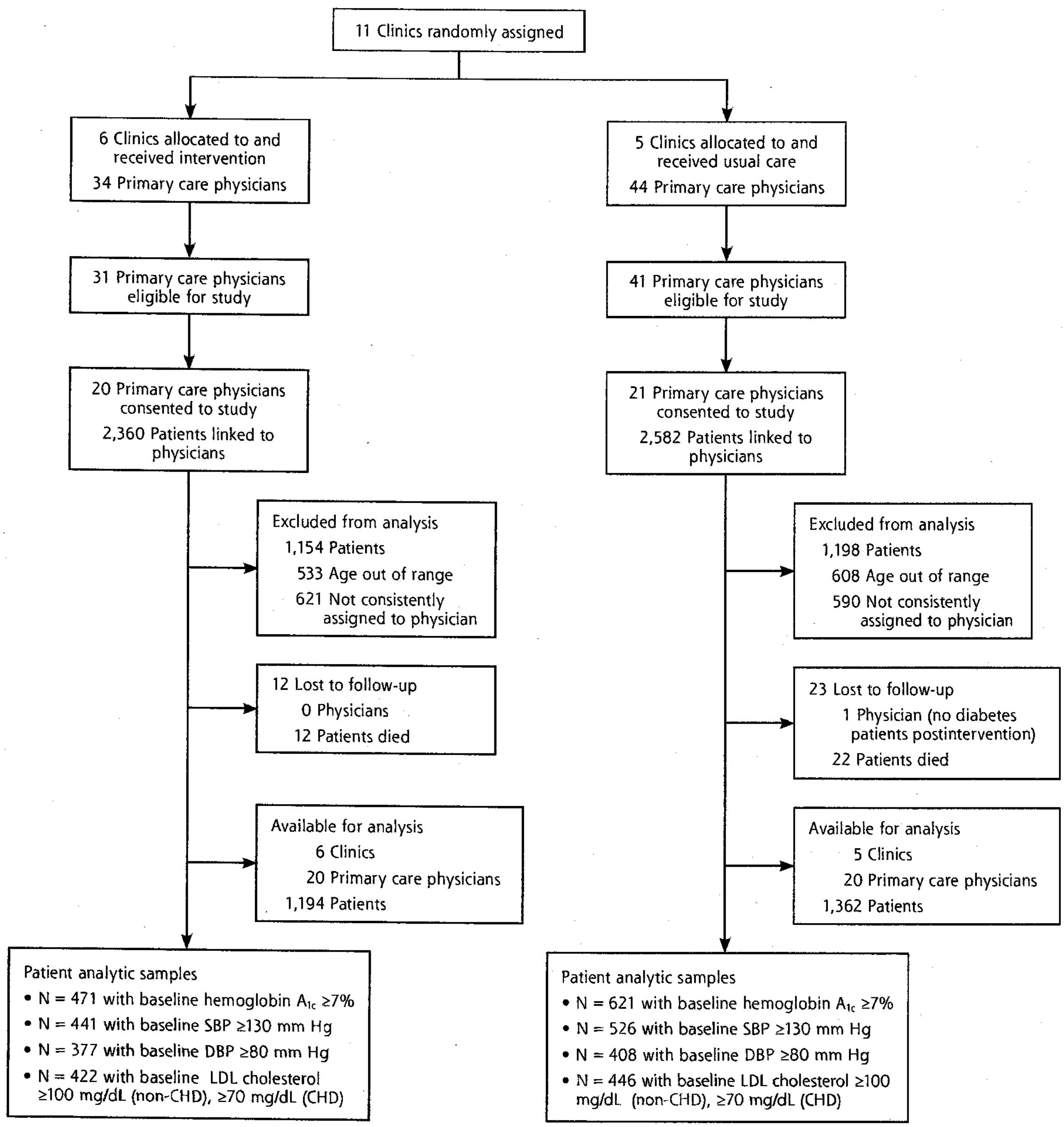
Denominators for the analysis of test rates, encounter rates, and numbers of tests and encounters included the full set of eligible patients linked to study-consenting physicians. Patients with diabetes encounters in the postintervention period and not at goal at baseline (eg, hemoglobin A_{1c} ≥7%, blood pressure ≥130/80 mm Hg, LDL cholesterol ≥100 mg/dL [≥70 mg/dL for coronary heart disease]) comprised the denominator for analysis examining change in hemoglobin A_{1c} levels. Patients with diabetes encounters and at goal at baseline (eg, hemoglobin A_{1c} <7%, systolic blood pressure <130 mm Hg, diastolic blood pressure <80 mm Hg, LDL cholesterol <100 mg/dL [<70 mg/dL for coronary heart disease]) comprised the denominator for analysis examining maintenance of clinical goals at the last follow-up measurement. For analyses of laboratory values, patients missing a value at baseline were not included in the analysis because we were unable to determine whether such cases were at goal at baseline. Patients without a postintervention value, however, were included through restricted maximum likelihood estimation, which uses information from patients with partially missing data.[35] A priori sample size calculations assumed an analytic sample of 500 diabetes patients per study arm, based on 20 physicians with 25 diabetes patients not at goal on hemoglobin A_{1c} measurements. Effective patient sample size was estimated as $n = 291$ per arm because of clustering of patients within physicians (estimated intraclass correlation coefficient = 0.03). This study was designed with 80% power to detect a difference of 0.3% in hemoglobin A_{1c} levels between study arms, with a 2-tailed $\alpha = .05$; α levels were not adjusted for testing 3 principal dependent variables.

RESULTS

Of the 11 clinics, 6 were randomly allocated to the study arm, and 5 to the usual care arm. From these clinics 40 physicians enrolled in the study, 20 in each study arm, with 2,556 eligible patients, 1,194 in the intervention arm, and 1,362 in the control arm. The allocation of clinics, physicians, and patients to study arm is shown in Figure 2.

Attributes of study participants are displayed in Table 1. At baseline, 47.8% of diabetes patients had hemoglobin A_{1c} levels of <7%, 59.1% had systolic blood pressures of <130 mm Hg, 65.6% had diastolic blood pressures of <80 mm Hg, and 59.9% had LDL cholesterol <100 mg/dL. The range of diabetes patients per study-enrolled physician was 10 to 100 with a mean of 49.7 (SD = 25.0). Randomization at the clinic level resulted in an intervention arm with a higher proportion of male and white patients, and with higher baseline diastolic blood pressure and LDL cholesterol values than patients in the control arm. Intervention arm clinics had a higher proportion of family practice physicians than control arm clinics.

Figure 2. Diagram illustrating randomization and disposition of clinics, primary care physicians, and diabetes patients.



CHD = coronary heart disease; DBP = diastolic blood pressure; hemoglobin A_{1c} = glycated hemoglobin; LDL = low-density lipoprotein; SBP = systolic blood pressure.

In 4-level random intercept models (measurement occasion nested within patient, physician, and clinic), intraclass correlations (ICCs) at the clinic level were small, with values of ICC ≤0.0002 for hemoglobin A_{1c}, systolic and diastolic blood pressures, and LDL cholesterol. Because of the low ICCs at the clinic level, 3-level models are presented by dropping the random intercept term for clinic.

Table 2 shows relatively high baseline and follow-up blood pressure and LDL cholesterol test rates, and little intervention effect on these measures during the study period. Proportion of patients with a hemoglobin A_{1c} test increased more in the intervention than control group ($P = .045$), but the mean number of hemoglobin A_{1c} ($P = .09$) and LDL cholesterol tests ($P = .09$) per patient was not affected by the intervention.

Table 3 shows that hemoglobin A_{1c} levels, systolic and diastolic blood pressures, and LDL cholesterol values each significantly improved with time in both study arms (all $P < .001$). Intervention arm patients had a significantly greater (–0.26%) improvement in hemoglobin A_{1c} levels than control arm patients (95% confidence interval [CI], –0.06% to –0.47%; time×condition $P = .01$). Although intervention and control arm patients had similar decreases in systolic blood pressures, intervention arm patients with controlled systolic blood pressure at

Table 1. Characteristics of Study Physicians and Diabetes Patients Linked to Those Study Physicians at Intervention and Control Clinics

Variable	Intervention Clinic	Control Clinic	*P* Value[a]
Patients			
Total No.	1,194	1,362	
Mean age (SD), y	57.0 (10.7)	57.5 (10.1)	.23
Female, %	46.7	54.5	<.001
White race, %	82.8	70.6	<.001
Coronary heart disease preintervention, %	12.1	12.6	.75
Congestive heart failure preintervention, %	2.9	3.6	.35
Preintervention first glycated A_{1c}, mean (SD) [median], %	7.4 (1.68) [7.0]	7.4 (1.67) [7.0]	.47
Preintervention first systolic blood pressure, mean (SD) [median], mm Hg	127.3 (17.4) [126]	126.8 (17.1) [125]	.40
Preintervention first diastolic blood pressure, mean (SD) [median], mm Hg	74.5 (10.9) [74]	73.5 (10.5) [74]	.023
Preintervention first LDL cholesterol value, mean (SD) [median], mg/dL	99.4 (34.5) [94]	95.9 (33.8) [90]	.019
Primary care physicians			
Total No.	20	20	
Age, mean (SD), y	49.2 (9.9)	50.2 (7.3)	.71
Family physician,%	80.0	45.0	.02
Female physician, %	55.0	50.0	.75
Diabetes patients per physician, mean (SD), No.	43.7 (17.3)	55.8 (30.2)	.13

[a] *P* value derived from independent samples *t* test or Pearson χ^2.

Table 2. Rates and Counts of Diabetes Encounters, Glycated Hemoglobin Tests, Low-Density Lipoprotein Cholesterol Tests, and Blood Pressure Measures, Comparing Intervention and Control Clinics in the Preintervention and Postintervention Periods

	Intervention Clinic			Control Clinic				
Variable	Pre-intervention 12 mo	Post-intervention 12 mo	Change	Pre-intervention 12 mo	Post-intervention 12 mo	Change	Intervention Effect[a]	*P* Value[b]
Patients with 1 or more encounters or tests, proportion (95% CI)								
Diabetes encounters	.850 (.820-.876)	.949 (.932-.962)	.099[c]	.875 (.849-.897)	.956 (.941-.967)	.081[c]	.018	.78
Hemoglobin A_{1c} tests	.829 (.788-.864)	.940 (.919-.956)	.112[c]	.858 (.822-.888)	.929 (.906-.947)	.071[c]	.041	.045
Blood pressure measurements	.986 (.977-.991)	.988 (.980-.993)	.003	.986 (.978-.991)	.981 (.971-.987)	–.005	.008	.28
LDL cholesterol tests	.819 (.779-.854)	.871 (.838-.899)	.052[d]	.846 (.809-.876)	.865 (.831-.892)	.019	.033	.14
Encounters or tests done per patient, mean (95% CI), No.								
Diabetes encounters	3.9 (3.6-4.4)	4.5 (4.1-4.9)	0.49[d]	4.4 (4.1-4.8)	5.1 (4.7-5.5)	0.68[c]	–0.20	.33
Hemoglobin A_{1c} tests	2.0 (1.8-2.1)	2.4 (2.2-2.5)	0.41[c]	2.0 (1.8-2.2)	2.3 (2.2-2.5)	0.31[c]	0.11	.09
LDL tests	1.4 (1.2-1.5)	1.5 (1.4-1.7)	0.17[d]	1.4 (1.3-1.6)	1.5 (1.4-1.6)	0.08	0.09	.09

Hemoglobin A_{1c} = glycated hemoglobin; CI = confidence interval; LDL = low-density lipoprotein.

[a] The intervention effect column illustrates the differential amount of change in the intervention arm relative to the control arm comparing pre- with postintervention.

[b] *P* value associated with the time × condition term in a generalized linear mixed model with repeated time measurements, study arm, and their interaction.

[c] $P < .001$.

[d] $P < .01$.

[e] $P < .05$.

Table 3. Changes and Proportion of Adult Diabetes Patients at Goal on Glycated Hemoglobin, Blood Pressure, and LDL Cholesterol Measures Among Intervention and Control Group Primary Care Physicians and Clinics in the Preintervention (Baseline) and Postintervention Periods

		Intervention Clinic			Control Clinic				
Variable	No.	Baseline	Post-intervention	Change	Baseline	Post-intervention	Change	Intervention Effect[a]	P Value[b]
Hemoglobin A_{1c}, mean (SE), %	1,092	8.5 (0.09)	7.9 (0.09)	−0.58[c]	8.4 (0.08)	8.1 (0.08)	−0.32[c]	−0.26	.01
Hemoglobin A_{1c} <7%, % (SE)	1,144		78.4 (2.0)			79.2 (2.0)		−0.8	.80
SBP, mean (SE), mm Hg	894	141.3 (0.70)	130.5 (0.70)	−10.8[c]	141.6 (0.69)	131.5 (0.69)	−10.1[c]	−0.70	.56
SBP <130 mm Hg, % (SE)	1,506		80.2 (1.6)			75.1 (1.6)		5.1	.03
DBP, mean (SE), mm Hg	731	85.1 (0.52)	76.8 (0.52)	−8.3[c]	84.6 (0.51)	77.1 (0.51)	−7.5[c]	−0.82	.38
DBP <80 mm Hg, % (SE)	1,669		85.6 (1.4)			81.7 (1.5)		3.9	.07
LDL cholesterol, mean (SE), mg/dL	868	122.3 (1.7)	97.9 (1.8)	−24.4[c]	124.1 (1.7)	98.3 (1.8)	−25.8[c]	1.37	.62
LDL cholesterol <100 mg/dL (or <70 mg/dL if heart disease), % (SE)	1,362		85.2 (1.6)			83.9 (1.5)		1.4	.53

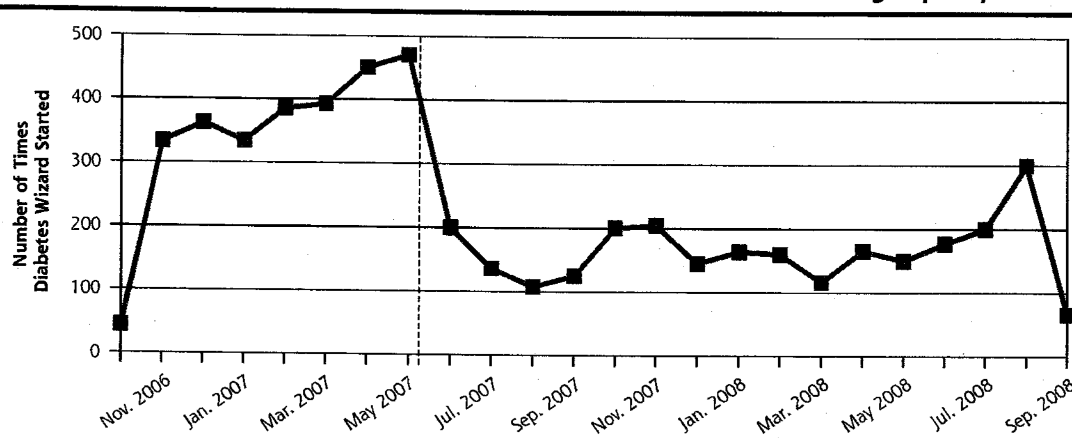
DBP = diastolic blood pressure; hemoglobin A_{1c} = glycated hemoglobin; LDL = low-density lipoprotein; SBP = systolic blood pressure; SE = standard error.

[a] The intervention effect column illustrates the differential amount of change in the intervention arm relative to the control arm comparing before and after the intervention.

[b] For mean value analysis, *P* value associated with the time × condition term in a general linear mixed model with repeated time measurements, study arm, and their interaction. For proportion at goal analysis, *P* value associated with study arm.

[c] *P* <.001.

Figure 3. Diabetes Wizard use during and after intervention for the intervention group only.



Note: Frequency of Diabetes Wizard use per month in intervention clinics shown on the vertical axis. Incentives and feedback on use of the Diabetes Wizard were provided from November 2006 to mid-May 2007. Sustained use of the Diabetes Wizard clinical decision support tool was observed at a lower rate after incentives and feedback stopped.

baseline were more likely to remain in control than control arm patients (80.2% vs 75.1%, $P = .03$). The intervention had no significant positive or negative impact on diastolic blood pressure and LDL cholesterol values or proportion remaining in control for hemoglobin A_{1c}, diastolic blood pressure, or LDL cholesterol values. Intervention benefits on hemoglobin A_{1c} levels occurred in both sexes and in both white and nonwhite patients.

During the 6-month period when use of the EHR-based clinical decision support system was reinforced by financial incentives and feedback, the Diabetes Wizard was opened at 62.6% of all visits made by diabetes patients to intervention physicians. After discontinuation of incentives and feedback, use of the Diabetes Wizard at the intervention clinics persisted at a lower level for 12 more months (Figure 3). Control group clinics did not have access to the intervention during the 18-month study. In a postintervention survey of 20 intervention group physicians, 17 of 18 respondents reported being completely satisfied or satisfied with this decision support system.

During the 6-month intervention period, physicians were asked to complete the Visit Resolution Form at the conclusion of each visit at which the Diabetes Wizard was used. Physicians reported intensifying glucose treatment in 536 of 866 (61.9%) visits when the hemoglobin A_{1c} level was >7%. Blood pressure treatment was intensified at 363 of 832 visits (43.6%) when blood pressure was >130/80 mm Hg at that visit; note that Diabetes Wizard deployed whenever the current blood pressure was ≥130/80 mm Hg, even if the patient's blood pressure was within target range at the prior visit. Rates of lipid treatment intensification were lower at 310 of 1,652 visits (18.8%) when lipids were not at goal. Analysis of EHR data on newly prescribed drugs, however, did not show significantly different rates for those with a hemoglobin A_{1c} level of ≥7% (10.7% vs 10.5%, $P = .86$) or blood pressure of ≥130/80 mm Hg (13.9% vs.14.0%, $P = .98$), although new lipid drugs were prescribed more often in the intervention group for those with a LDL cholesterol value of ≥100 mg/dL (9.1% vs 5.6%, $P = .001$). These data, taken together, suggest that many of the treatment intensifications reported by intervention group physicians were related to drug dose titrations (rather than newly prescribed drugs), or to lifestyle advice or interventions.

DISCUSSION

These data show that an EHR-based clinical decision support system led to modest but significant improvements in glucose control and some aspects of blood pressure control. Primary care physicians reported high levels of satisfaction with the intervention and had high rates of use of the clinical decision support system during the intervention period and continued to use the technology for more a year after incentives and feedback were discontinued, although at a lower rate. Patients of intervention physicians who were and were not exposed directly to the clinical decision support system had comparable improvement in hemoglobin A_{1c} levels and systolic blood pressure during the follow-up period. This finding suggests that physicians were able to transfer what they learned from using the clinical decision support system with some patients to the care of other patients—an important challenge and desirable finding in learning research.

This clinical decision support system used a strategy of personalization. As Figure 2 shows, clinical decision support went beyond prompts and reminders to include drug-specific treatment suggestions based on each patient's current treatment; distance from clinical goal, comorbidities, and renal and hepatic function. This type of clinical decision support system simultaneously standardizes and personalizes diabetes care. As personalization of chronic disease care increases in the coming era of genomic medicine, EHR-embedded clinical decision support may become an essential tool needed to systematically process complex risk prediction data and then accurately identify appropriate clinical goals and high-priority treatment options for each patient at each clinical encounter.[36,37]

In this study, the use of EHR-based clinical decision support technology was reinforced by changes in clinic rooming procedures, changes in nurse roles, and provision of incentives to physicians and clinic staff—elements that were lacking in previous failed attempts to implement EHR-based clinical decision support. Physicians were provided clinical decision support information immediately before the start of the visit to facilitate visit planning.[8,38] Although this intervention was well-received by physicians, it is uncertain whether high levels of use and satisfaction can be replicated when financial compensation is replaced by other incentives, such as pay-for-performance programs or public reporting of chronic disease quality of care.[39]

The study was conducted in a medical group with relatively good baseline diabetes care, and the magnitude of clinical improvement was quite modest. Even so, these modest results provide proof of concept that (1) under certain circumstance primary care physicians will use sophisticated point-of-care clinical decision support systems, and (2) when such clinical decision support systems are used, they can improve several intermediate outcomes of chronic disease care. Further efforts to strengthen the impact of clinical decision support on chronic disease care are justified and are already underway. Such efforts include prioritizing care recommendations based on benefit to the patient, enhancing the clinical decision support interface with physicians, and developing engaging and informative interfaces with patients that elicit and integrate patient preferences for care.[40]

Interpretation of our results is limited by several factors. First, the study site had relatively good baseline levels of diabetes care. The impact of clinical decision support in other practice settings may be greater or less than what we observed. Second, studies that explore alternative and less-expensive incentive strategies are needed.[41] Third, additional work is needed to elucidate more precisely the specific mechanisms that were responsible for the observed effects of this intervention.

Despite these limitations, our data provide proof-of-concept that an EHR-based clinical decision support system can improve key intermediate outcomes of diabetes care in primary care settings. The observed clinical impact, although modest, is comparable to that achieved by many disease management or patient education programs that are more expensive.[42-46] EHR-based clinical decision support is scalable and can be used in conjunction with additional care improvement strategies. In the coming era of personalized medicine, clinical decision support strategies capable of simultaneously standardizing and personalizing clinical care will likely become an essential tool in primary care, and investments to further enhance the effectiveness of this technology are urgently needed.

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Key words: Electronic health records; diabetes mellitus; quality of health care; quality improvement; glucose control; blood pressure control; primary health care; randomized trial

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Effectiveness of Clinical Decision Support in Controlling Inappropriate Imaging

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Background: Decision support systems for advanced imaging are being implemented with increased frequency and are mandated under some new governmental health care initiatives. However, evidence of effectiveness in reducing inappropriate imaging utilization is limited.

Methods: A retrospective cohort study was performed of the staged implementation of evidence-based clinical decision support built into ordering systems for selected high-volume imaging procedures: lumbar MRI, brain MRI, and sinus CT. Brain CT was included as a control. Imaging utilization rates (number of patients imaged as a proportion of patients with selected clinical conditions) and overall imaging utilization before and after the interventions were determined from billing data from a regional health plan and from the institutional radiology information system.

Results: The use of imaging clinical decision support was associated with substantial decreases in the utilization rate of lumbar MRI for low back pain (risk ratio, 0.77; 95% confidence interval, 0.87-0.67; $P =$ .0001), head MRI for headache (risk ratio, 0.76; 95% confidence interval, 0.91-0.64; $P = .001$), and sinus CT for sinusitis (risk ratio, 0.73; 95% confidence interval, 0.82-0.65; $P < .0001$). Utilization rates for the head CT control group were not significantly changed. There was a corresponding significant decrease in overall imaging volumes (all diagnoses) for lumbar MRI, head MRI, and sinus CT, with no observed effect for the head CT control group.

Conclusion: Targeted use of imaging clinical decision support is associated with large decreases in the inappropriate utilization of advanced imaging tests.

Key Words: Imaging utilization, appropriateness, computer decision support

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INTRODUCTION

Health care expenses in the United States continue to spiral upward, now representing more than 17% of the gross domestic product [1]. Imaging is one of the most important contributors to health care costs, encompassing more than 14% of Medicare Part B expenditures [2-4]. Although identified as the most significant advance in medicine in the past several decades [5], imaging has become a target for cost containment. A major driver for increasing imaging cost is the inappropriate utilization of advanced imaging, including CT and MRI [4,6-8]. Accordingly, health care providers are under increasing pressure to limit imaging to evidence-based applications.

Payers have initiated several approaches to control imaging utilization, including external authorization methods and clinical decision support systems [9]. Clinical decision support systems are point-of-order decision aids, usually through computer order entry systems, that provide real-time feedback to providers ordering imaging tests, including information on test appropriateness for specific indications. Such systems may be purely educational, or they may be restrictive in not allowing imaging test ordering to proceed when accepted indications are absent. Although data on the efficacy of imaging clinical decision support systems are limited [10], adoption is increasing and has spread to include state-level initiatives in Washington [11] and Minnesota [12]. Imaging clinical decision support systems can range from simple aids

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for small numbers of studies and indications to broad systems encompassing the thousands of possible pairs of indications and imaging procedures. To date, there are no published studies demonstrating decreased imaging utilization after implementation of imaging clinical decision support, though a decrease in the rate of growth of utilization of imaging has been reported. We hypothesized that imaging clinical decision support could decrease imaging utilization when targeted to select imaging studies and indications that included high volumes and high cost [13,14].

The objective of this investigation was to identify changes in imaging utilization associated with the initiation of an imaging management program based on clinical decision support for selected CT and MRI studies at a single integrated health care delivery system.

METHODS

The overall study design was a retrospective cohort evaluation of the effect of the staged implementation of a clinical decision support system on imaging utilization, with historical and concurrent controls. The study was granted a waiver from the institutional review board.

Setting

The study setting was Virginia Mason Medical Center, an integrated multidisciplinary health care network in the Pacific Northwest with approximately 450 physicians, 800,000 outpatient visits, 17,000 hospital visits, and 260,000 radiology examinations annually. The institution includes a central urban campus as well as multiple suburban satellite imaging and outpatient care centers.

Intervention

Lumbar MRI, head MRI, and sinus CT were identified as frequently performed, high-cost procedures with high variability in utilization [2,14,15] and with at least some medical evidence to guide appropriate utilization [16]. Accordingly, these procedures were targeted for the initial implementation of the decision support system, rather than a more global approach. The intervention was based on a set of locally derived evidence-based decision rules for when imaging is appropriate. These decision rules were developed by Virginia Mason providers from the involved specialties after review of national and international evidence-based guidelines and primary literature and were vetted extensively in the institution before implementation. The system was not designed to be comprehensive but rather to focus on areas where there was potential for improvement, which we defined as high variability, high utilization, and medical evidence to enable guideline development.

The actual imaging intervention was built around several assumptions: (1) that physician education alone is insufficient to change practice, (2) that patient and provider expectations mandate that an alternative be offered if imaging is denied, and (3) that the intervention should occur at the point of care, to avoid disrupting care.

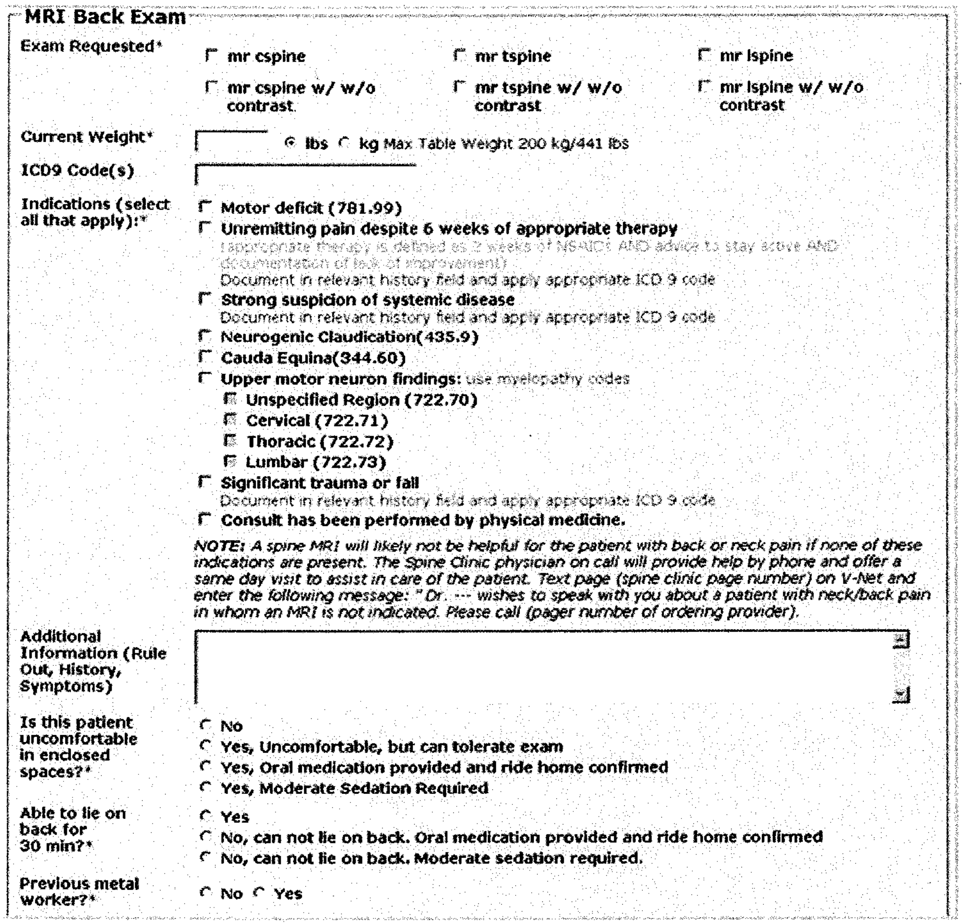
The imaging intervention was a mandatory series of questions at the point of care in the imaging order system that confirmed adherence to the institutional evidence-based imaging indications (Figure 1). Providers ordering studies were required to check appropriate boxes corresponding to approved imaging indications. Failure to document compliance with approved indications would prevent the online order from being activated. The intervention was systemwide but was limited to outpatient imaging (excluding the emergency department). The imaging clinical decision support intervention was accompanied by an institutional educational effort including e-mails, small conferences, and personal communication. Additional periodic audits were performed with communication with any providers who ordered imaging but had not documented appropriate indications in the medical record. The evidence-based imaging protocols for MRI for low back pain and head MRI for headache were implemented in 2005. The protocol for sinus CT for suspected sinus disease was implemented in 2007.

Because of patient and provider expectations, alternatives to imaging that might be beneficial to patients were also offered, with information provided in the order entry system. For lumbar back pain, physical therapy was offered, with availability of same-day or next-day consultation with a (nonoperative) spine specialist. For headache and sinus disease, prompt neurologist or allergist consultation was available. The subspecialist consultants were authorized to override the clinical decision support system when they considered imaging clinically indicated.

Data Sources

To determine the effectiveness of the intervention in decreasing inappropriate imaging utilization, we used *International Classification of Disease,* 9th ed., *Clinical Modification* (ICD-9-CM) and Common Procedural Terminology® (CPT®) codes to interrogate the data records of a large regional health insurance carrier to determine the rates of relevant imaging for patients with specified diagnoses cared for in our system. Data were available for January 1, 2003, through December 31, 2009. For each of the clinical conditions (low back pain, headache, and sinusitis), we identified corresponding sets of ICD-9-CM codes. For the patients with the clinical scenarios defined by the codes, we used CPT codes to determine the utilization of relevant imaging. For the low back pain, the included ICD-9-CM codes were 344.6,

Fig 1. Sample imaging clinical decision support tool for low back pain and lumbar MRI.



720, 721.3, 721.42, 721.5 to 721.9, 722.10, 722.32, 722.52, 722.73, 722.83, 722.93, 724.02, 724.2 to 724.9, 846, and 847.2 to 847.4. For lumbar MR, the included CPT codes were 72148, 72149, and 72158, encompassing all lumbar MR examinations. For headache, the included ICD-9-CM codes were 307.81, 339, 346, and 784.0. The associated CT and MR codes were 70450, 70460, 70470, 70541, 70551, 70552, and 70553, encompassing all head MR and CT examinations. The sinusitis ICD-9-CM codes were 461, 473, and 478.1. The sinus CT CPT code was 70486, which included all CT sinus studies.

Total volumes of imaging were also determined from the radiology information system (IDX Imagecast 10; GE Healthcare, Fairfield, Connecticut) on the basis of the CPT codes detailed above. These volumes are irrespective of payer.

Data Analysis

Primary analysis was a comparison of the rate of imaging in the years preceding the intervention with the rate of imaging in the years after the intervention, for the single commercial payer. For imaging rate, the numerator was the number of patients imaged, and the denominator was the total number of patients with a given clinical condition. Imaging rate rather than absolute number of studies was used in the primary analysis to control for temporal variation in the number of patients evaluated with a given clinical condition. We assessed for significant change in imaging rate after the intervention, adjusted for temporal trends, using the likelihood ratio test to compare linear regression models of rate as a function of year vs rate as a function of year and intervention. Estimates of the absolute magnitude in decrease in imaging rate after the intervention were made by comparing the imaging rate in the year before the intervention with the average imaging rate in the years after the intervention, using χ^2 analysis. For the magnitude analysis, the actual year of intervention was excluded. Similar analysis was also performed for head CT as an internal control and also to ensure that there was no substitution of head CT for head MRI after the intervention. Because there was no intervention for head CT, for the analysis, the intervention year for head CT was considered to be 2005, the year of the head MR intervention.

Secondary analysis included the determination of changes in trends and overall volumes of the specific imaging studies associated with the intervention,

Table 1. Imaging volume, patient volumes, and imaging rate

Study	2003	2004	2005	2006	2007	2008	2009
Lumbar MRI for low back pain	261	292	402	290	296	329	355
Head MRI for headache	149	165	224	171	186	186	191
Sinus CT for sinusitis	285	321	522	497	448	355	305
Head CT for headache	100	100	143	130	142	147	143
Headache patients	1,062	1,111	1,684	1,559	1,535	1,699	1,682
Sinusitis patients	2,164	2,123	3,502	2,838	2,812	2,623	2,525
Low back pain patients	2,303	2,302	3,373	3,114	3,117	3,342	3,497
Lumbar MRI rate*	0.113	0.127	***0.119***	0.093	0.095	0.098	0.102
Brain MRI rate*	0.140	0.148	***0.133***	0.110	0.121	0.110	0.114
Sinus CT rate*	0.132	0.151	0.149	0.175	***0.159***	0.135	0.121
Head CT rate*	0.094	0.090	0.085	0.083	0.093	0.087	0.085

Note: Data on patients from a single regional commercial payer. Numbers in boldface italics represent the year of intervention (no intervention in the head CT control group).
*Rate is defined as the number of patients with a given procedure divided by the total number of patients with a specific clinical condition.

throughout the network (for all purchasers and for all diagnoses). Overall volumes were not adjusted for clinical condition but provide an estimate of overall effect of the intervention on health care utilization and cost. We assessed for significant change in overall volume of imaging studies after the intervention, adjusted for temporal trends, using the likelihood ratio test to compare linear regression models of volume as a function of year vs volume as a function of year and intervention. Finally, we assessed for temporal change in imaging rate and imaging volume before and after the intervention using linear regression.

Results are expressed as the risk ratio (RR) for imaging, with a value of <1.0 indicating decreased imaging after the intervention. In addition, results are reported as a percentage change (reduction) in imaging. Statistical analysis was performed using Stata version 10 (StataCorp LP, College Station, Texas).

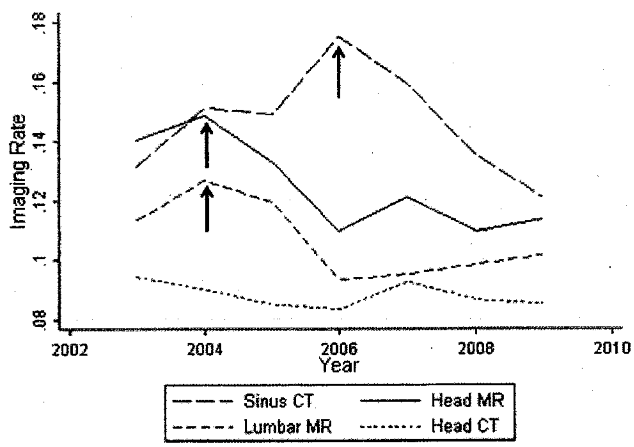


Fig 2. Imaging rates vs time for patients with disease-specific billing codes from a single regional payer. Arrows indicate the year before the intervention.

RESULTS

We found clinically and statistically significant decreases in utilization rates for the targeted procedures after the intervention. Table 1 details the raw counts of imaging procedures, as well as the counts of patients with the corresponding diagnoses and the rate of imaging among affected individuals before and after the intervention. The rates of imaging after the intervention were 23.4% lower for low back pain lumbar MRI (RR, 0.77; 95% confidence interval [CI], 0.87-0.67; $P <$ .001), 23.2% lower for headache head MRI (RR, 0.76; 95% CI, 0.91-0.64; $P =$ .001), and 26.8% lower for sinusitis sinus CT (RR, 0.73; 95% CI, 0.82-0.65; $P <$ .001). The peak rate occurred in the year before the intervention for all 3 imaging procedures (Figure 2). The decrease in imaging rate was significant in the multiple regression analysis after adjustment for temporal trend for lumbar MRI ($P =$ .001), head MRI ($P =$ .05), and sinus CT ($P =$ .003), with a nonsignificant result for the head CT control group ($P =$ .88).

After the intervention-associated decline, the rate of MRI of the lumbar spine increased at approximately 3% per year (RR, 1.003; 95% CI, 1.002-1.004; $P =$ .007), while there was no evidence of an increase in rate for head MRI (RR, 1.000; 95% CI, 0.99-1.01, $P =$ .99). Postintervention trend analysis for head MRI, head CT, and lumbar MRI was limited by the small sample size (4 years). Sinus CT could not be explored for trend after the intervention.

For the head CT control group, we identified no significant change in the rate of imaging (RR, 0.97; 95% CI, 1.21-0.78, P = .37) after the head MRI intervention (no head CT intervention was performed). There was also no trend in head CT rate in the years after the intervention (RR, 1.0; 95% CI, 0.99-1.01, P =.96).

Secondary analysis revealed that the decision support intervention was also associated with decreases in the overall volumes of lumbar MRI, head MRI, and sinus CT studies, regardless of diagnosis. For head MRI, the volumes after the intervention were significantly lower in the regression model (P < .0001) after adjustment for temporal volume trends and continued to decrease after the intervention by 162 studies per year (95% CI, 88-236; P = .01). For lumbar MRI, adjusted volumes after the intervention were significantly lower (P = .005) than before the intervention, with no significant change in subsequent years (estimated subsequent decrease, 34; 95% CI, decrease 279 to increase 210, P = .60). For sinus CT, there was a significant decrease in adjusted volumes after the intervention (P = .010), with insufficient data to assess for a further decrease. For the head CT control group, there was no significant change in overall volume associated with the time of the head MRI intervention (P = .52).

DISCUSSION

Clinical decision support is potentially an ideal method for improving the evidence-based use of imaging. Clinical decision support tools have the desired properties of being educational, transparent, efficient, practical, and consistent [4]. However, data on the effectiveness of clinical decision support is limited. Prior investigation has focused on the use of a global system encompassing virtually all CT and MRI studies and indications and has demonstrated only a relative attenuation in the rate of increase in imaging utilization. However, in the prior report, actual imaging utilization of both CT and MRI continued to grow [10].

In this report, we detail a significant and sustained decrease in the utilization of targeted advanced imaging studies through the use of clinical decision support based on a simple set of locally derived evidence-based imaging guidelines. Our approach has several important innovations from other reports of imaging clinical decision support systems [9,10] that may have contributed to success. We targeted areas of high and potentially inappropriate utilization, concentrating effort where there is potential for benefit rather than globally applying computer decision support to all higher imaging, as others have advocated [9,10]. Also, we incorporated denial of imaging for inappropriate indications, preventing orders that did not meet evidence-based indications from proceeding in the computer order entry system. Finally, we offered the provision of alternate resources, in the form of prompt specialist consultation or therapy, where indicated.

The study setting likely had a substantial effect on the success of the program. The intervention was performed at Virginia Mason Medical Center, a multispecialty integrated health care network, with all providers being salaried employees of the institution. Thus, financial incentives and risks were shared by the entire institution and providers. Although the providers received no direct financial incentive or avoidance of precertification, there was pressure on the institution from local commercial payers to take an active role in limiting the overutilization of imaging. The clinical decision support intervention, coupled with rapid access to appropriate clinical care, increased the quality and efficiency of providing care at the institution, potentially providing overall benefit despite decrease in radiology volumes. This overall institutional benefit allowed radiology to participate in practice improvements that may have resulted in decreased radiology reimbursement. However, it is also clear that to the extent that financial incentives in the health care system are based on volumes and reward inefficiency through overutilization, the overall institution could be at a financial disadvantage as a result of providing better quality, more evidence based care.

A second advantage to being a multispecialty network is that most referrals for imaging were from within the system, enhancing the ability to influence physician ordering behavior. The elimination of unnecessary imaging was defined by the institution as a component of quality, motivating providers to support the mandatory clinical decision support program. Also, the concept of evidence-based medicine had wide penetration throughout our institution, with a concordant high acceptance of evidence-based imaging protocols. In addition, the institutional culture, with a pervasive focus on efficiency and Lean health care management methodology [17], provided a framework to enable relatively rapid change.

There have been important challenges in the implementation of the imaging clinical decision support system. Although built using evidence-based medicine methodology, our protocols were often limited by the availability of quality data and nationally accepted evidence-based guidelines. Accordingly, global evidence was applied locally through the work of institutional evidence-based medicine teams, relying on local provider expertise only where evidence was lacking [18]. However, because our protocol development process was local, critical buy-in from stakeholders was achieved in the development stage, enhancing implementation throughout the network.

We acknowledge the limitations of this analysis. The study was performed retrospectively with data from only 7 years because earlier data are not available within our data systems. Temporal events independent of our intervention may affect the rates of imaging, and although we did adjust for year in the regression analyses, residual confounding may exist. The use of head CT as an internal control provided some reassurance that there was not a generalized trend toward a decrease in imaging utilization over the study time frame, as we observed no significant change in head CT rate and volume during the study period. In addition, the fact that the CT sinusitis intervention occurred 2 years after the lumbar and brain MR interventions, but with similar results, lends strength to the argument that the decrease in imaging is a function of the intervention. Finally, national trends in the time frame of this study have reported continued substantial increases in imaging volumes, in sharp contrast to our decreases [19,20]. We also acknowledge that other factors in addition to the clinical decision support likely contributed to the success of our program, including the Hawthorne effect, peer pressure, and the fact that the results of our periodic audits would potentially be available to the referring physician's employer.

Also, the analysis was based on administrative data without patient identifiers. Therefore, we were not able to directly evaluate the appropriateness of imaging for each subject. It is possible that inappropriate utilization continues. We also lack the ability to confirm that the decrease in utilization is appropriate. However, given that the computer order entry intervention is based on the best available evidence, we have confidence that appropriateness of imaging has been improved. It is also possible that patients in whom imaging was not performed at our institution sought care elsewhere. This would provide an argument for more global adoption of evidence-based imaging protocols but not lessen the significance of our results in improving care at our institution.

With clinical decision support or other barriers to image ordering, there is always the potential that providers will "game" the system, developing ways to continue to order inappropriate studies. We did not audit individual requests of imaging to determine the outcome when a request was initially denied by the system. However, we report our results in terms of imaging rate and total volume of imaging studies. Unlike appropriateness scores or other intermediate metrics, imaging rate and total imaging volume represent actual utilization outcomes that cannot be "gamed" by altering indications or other techniques.

Our data were acquired in the real world of quality improvement, so we lack the ability to randomize or to perform a multicenter controlled study. Furthermore, the limited number of institutions with a focus on Lean process and quality may restrict the generalizability of our results. However, we do provide evidence of the potential value of targeted imaging clinical decision support and provide an example of a successful approach. Finally, as of this report, we have implemented imaging clinical decision support only for a limited number of imaging studies and indications. However, a large proportion of advanced imaging, and likely a large portion of the potential for improvement, occurs in a relatively limited number of high-use, high-cost procedures [14,15].

In conclusion, we demonstrate that the implementation of imaging clinical decision support for selected high-utilization imaging procedures can have a substantial effect on imaging rate and volume in an integrated multidisciplinary health care network. The use of such systems can aid the elimination of unnecessary imaging, increasing both patient safety and quality and decreasing health care costs.

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The Kaiser Permanente Electronic Health Record: Transforming And Streamlining Modalities Of Care

EHRs can help achieve more-efficient contacts between patients and providers, while maintaining quality and satisfaction.

by Catherine Chen, Terhilda Garrido, Don Chock, Grant Okawa, and Louise Liang

ABSTRACT: We examined the impact of implementing a comprehensive electronic health record (EHR) system on ambulatory care use in an integrated health care delivery system with more than 225,000 members. Between 2004 and 2007, the annual age/sex-adjusted total office visit rate decreased 26.2 percent, the adjusted primary care office visit rate decreased 25.3 percent, and the adjusted specialty care office visit rate decreased 21.5 percent. Scheduled telephone visits increased more than eightfold, and secure e-mail messaging, which began in late 2005, increased nearly sixfold by 2007. Introducing an EHR creates operational efficiencies by offering nontraditional, patient-centered ways of providing care. [*Health Affairs* 28, no. 2 (2009): 323–333; 10.1377/hlthaff.28.2.323]

A GROWING BODY OF LITERATURE CONFIRMS the value of electronic health records (EHRs) in improving patient safety, improving coordination of care, enhancing documentation, and facilitating clinical decision making and adherence to evidence-based clinical guidelines.[1] However, less is known about EHRs' impact on the efficiency of outpatient care. A recent Congressional Budget Office (CBO) report notes the paucity of documented benefits of health information technology (IT) for providers and hospitals that are not part of integrated systems.[2] In this paper we report on the impact of implementing an integrated EHR system on the use of various types of ambulatory care in one Kaiser Permanente (KP) region as an example of impact throughout the entire system.

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KP is the largest U.S. not-for-profit integrated health care delivery system, serving 8.7 million members in eight regions. Members receive the entire scope of health care: preventive care; well-baby and prenatal care; immunizations; emergency care; hospital and medical services; and ancillary services, including pharmacy, laboratory, and radiology. Nationwide, KP employs approximately 156,000 technical, administrative, and clerical personnel and caregivers and 13,000 physicians.

KP HealthConnect

In 2004, KP began implementing KP HealthConnect, a comprehensive health information system with numerous functionalities, including (1) an EHR with comprehensive documentation across care settings—inpatient and outpatient, clinical decision support, and complete, real-time connectivity to lab, pharmacy, radiology, and other ancillary systems; (2) secure patient-provider messaging available through a member Web site that also provides personal health records; and (3) electronic interprovider messaging about care that is automatically incorporated into patients' records.

The purpose of our study was to examine the impact of KP HealthConnect on several types of ambulatory care patient contacts: outpatient, urgent care, and emergency department (ED) visits; external referrals; scheduled telephone visits; and secure patient-physician e-mail messaging.

Study Data And Methods

The KP Hawaii region was the first in Kaiser Permanente to fully implement KP HealthConnect in the outpatient setting. KP Hawaii has approximately 225,000 members, a figure that was consistent during the four-year study period.

We conducted a retrospective observational study using administrative data. The baseline year was 2004; KP HealthConnect implementation in primary care began in April and was completed in November. Implementation in specialty care was completed in June 2005, and the patient-provider secure messaging function became available in September 2005. The comparison year was 2007.

Data on rates of outpatient, urgent care, and ED visits; external referrals; scheduled telephone visits; and secure patient-physician messaging were extracted from the regional data warehouse.[3] Annual total office visit rates per region were stratified by primary care and specialty care and age/sex-adjusted to a fixed age/sex distribution over the time period, using four age categories (0–19, 20–44, 45–64, and 65+).

Our study included the entire regional membership, allowing us to use the Wilcoxon-Mann-Whitney test to assess the statistical significance of the changes between 2004 and 2007 in rates of total office visits, primary care visits, specialty care visits, scheduled telephone visits, secure patient-physician messaging, external referrals, urgent care visits, and ED visits.

Study Findings

■ **Office and telephone visits.** Age/sex-adjusted total office visits per member decreased 26.2 percent between 2004 and 2007 ($p < 0.001$), and total scheduled telephone visits per member increased nearly ninefold (Exhibit 1). Exhibit 2 summarizes the changes in office and telephone visits.

■ **Secure messaging.** In September 2005, KP Hawaii launched My Health Manager, the secure online patient-physician messaging function of KP HealthConnect. In the remaining months of 2005, members initiated more than 3,000 secure e-mail messages, a rate of 0.03 secure messages per member. In 2006, members sent nearly 25,000 messages (0.11 per member). In 2007, they sent more than 51,000 messages (0.23 per member). The increase between 2005 and 2007 was statistically significant ($p < 0.001$).

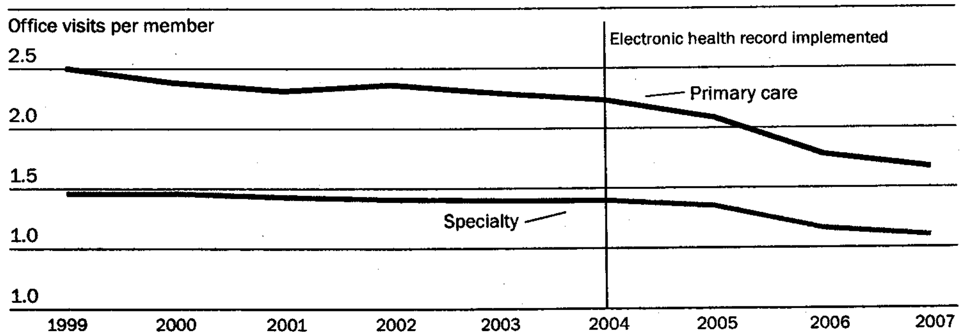
The total number of patient contacts via office and telephone visits and secure messaging increased 8.3 percent after EHR implementation, from 5.18 contacts per member per year in 2004 to 5.61 contacts per member per year in 2007 ($p < 0.001$).

■ **Other factors.** We explored other factors that could explain decreased use of ambulatory care visits. Enrollment in KP Hawaii did not change over the four-year study period, nor did the proportions of members over age sixty-five (12 percent) and those with at least one chronic condition (29 percent). The ratio of providers to members remained stable over time at 1.9 physicians per 1,000 members. The rate of referrals to external providers decreased 53 percent between 2004 and 2007 ($p < 0.001$).

The rate of ED and urgent care visits increased between 2004 and 2007—urgent care visits by 19 percent ($p < 0.001$) and ED visits by 11 percent ($p < 0.001$) (Exhibit 3).

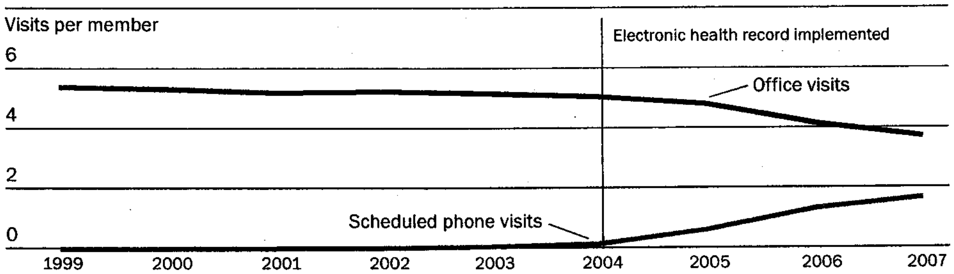
■ **Quality and patient satisfaction.** KP Hawaii captures Healthcare Effectiveness Data and Information Set (HEDIS) data as part of its routine quality surveil-

EXHIBIT 1
Changes In Office Visit Rates Among Kaiser Permanente (KP) Hawaii Members, 1999–2007



SOURCE: Authors' analysis using data from the Kaiser Permanente Hawaii Data Warehouse and secure messaging database.

EXHIBIT 2
Changes In Office Visit Versus Telephone Visit Rates Among Kaiser Permanente (KP) Hawaii Members, 1999–2007



SOURCE: Authors' analysis using data from the Kaiser Permanente Hawaii Data Warehouse and secure messaging database.

lance.[4] Between 2004 and 2007, many scores were not comparable over time because of changes in the HEDIS measure set. For the majority of measures that were comparable, performance remained stable during the study period (Exhibit 4). Overall quality was, at the least, maintained.

We were unable to use Consumer Assessment of Healthcare Providers and Systems (CAHPS) data to assess patient satisfaction because measures were not comparable across all years.[5] However, results from KP Hawaii member satisfaction surveys remained essentially unchanged. In 2004, 84 percent of surveyed KP Hawaii members rated their overall visit satisfaction at 8 or above on a scale of 1 to 10; in 2007, 87 percent did so. In 2004, 78 percent of KP Hawaii members rated the

EXHIBIT 3
Ambulatory Care Contact Per Member Rates Among Kaiser Permanente (KP) Hawaii Members, Selected Years 2004–2007

Type of contact	2004	2005	2007	Net change	Percent change[a]
Total office visits[b]	5.01	–[c]	3.70	–1.31	–26
Primary care	2.24	–[c]	1.67	–0.57	–25
Specialty care	1.40	–[c]	1.10	–0.30	–21
Scheduled telephone visits	0.17	–[c]	1.68	1.51	869
Secure e-mail messaging	–[d]	0.03	0.23	0.23	597
All ambulatory care contacts	5.18	–[c]	5.61	0.43	8
External referrals	0.04	–[c]	0.02	–0.02	–53
Urgent care	0.13	–[c]	0.15	0.02	19
ED visits	0.16	–[c]	0.18	0.02	11

SOURCE: Authors' analysis using data from the Kaiser Permanente Hawaii Data Warehouse and secure messaging database.
NOTE: ED is emergency department.
[a] All results are statistically significant ($p < 0.001$).
[b] The number of total office visits is greater than the sum of primary and specialty care visits because total office visits include care rendered by nurse practitioners, physician assistants, registered nurses, optometrists, social workers, and rehabilitative therapists, as well as physicians.
[c] Not applicable.
[d] Not available.

EXHIBIT 4
Healthcare Effectiveness Data And Information Set (HEDIS) Scores Of Kaiser Permanente (KP) Hawaii Members, 2004 And 2007

Measure	2004	2007	Trend[a]
Commercial population			
Childhood immunization status—combination 2	85.9%	85.9%	No change
Appropriate testing for children with upper respiratory infection	88.9	92.3	Favorable
Appropriate testing for children with pharyngitis	86.0	88.0	Favorable
Colorectal cancer screening	37.2	41.4	Favorable
Breast cancer screening in women ages 52–69	73.2	81.4	Favorable
Chlamydia screening for women			
Ages 16–20	52.3	60.0	Favorable
Ages 21–25	48.3	62.4	Favorable
All, ages 16–25	50.0	61.3	Favorable
Comprehensive diabetes care			
HbA1c testing	85.9	88.6	Favorable
Poor HbA1c control	35.0	40.4	Unfavorable
Use of imaging studies for low back pain	81.7	76.8	Favorable
Antidepressant medication management			
Effective acute-phase treatment	64.5	62.2	Unfavorable
Effective continuation-phase treatment	52.8	47.4	Unfavorable
Follow-up after hospitalization for mental illness			
Within 7 days	66.7	73.1	Favorable
Within 30 days	75.4	85.1	Favorable
Medicare population			
Colorectal cancer screening	51.8	58.9	Favorable
Breast cancer screening in women ages 52–69	78.8	87.6	Favorable
Comprehensive diabetes care			
HbA1c testing	93.9	96.8	Favorable
Poor HbA1c control	15.6	16.6	Unfavorable
Antidepressant medication management			
Effective acute-phase treatment	64.0	73.8	Favorable
Effective continuation-phase treatment	57.1	63.3	Favorable
Osteoporosis management in women with a fracture	36.6	27.9	Unfavorable

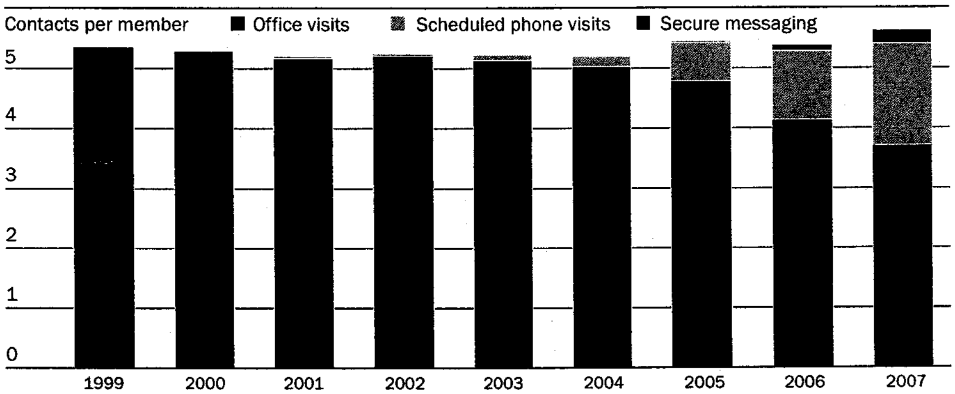
SOURCE: Kaiser Permanente Hawaii HEDIS data.
[a] Trends reflect changes in the HEDIS scores; no statistical significance testing was conducted.

level of interest and attention of their health care providers at 8 or above; in 2007, 79 percent did so. Additionally, in 2007, 90 percent rated their satisfaction with telephone visits at 8 or above.[6]

Discussion And Policy Implications

We examined the impact of an integrated EHR on ambulatory care use and found a 26.2 percent decrease in the annual age/sex-adjusted total office visit rate over four years. In 1999, office visits accounted for 99.6 percent of all ambulatory care contacts. Eight years later, they represented 66 percent of patient contacts. Scheduled telephone visits accounted for 30 percent of patient contacts, and secure messaging represented the remaining 4 percent (Exhibit 5). Between 2004

EXHIBIT 5
Distribution Of Patient Contacts Over Time Among Kaiser Permanente (KP) Hawaii Members, 1999–2007



SOURCE: Authors' analysis using data from the Kaiser Permanente Hawaii Data Warehouse and secure messaging database.

and 2007, these new modalities of care enabled an overall increase in patient contacts and access of 8 percent.

Although ED and urgent care use rose between 2004 and 2007, the increase represents only approximately 5 percent of the volume of the decrease in total office visit rates. Therefore, it is unlikely that the rise reflects a shift in the location of care from office-based sites to ED and urgent care settings. Further, the rise in ED and urgent care visit rates was delayed relative to the decrease in office visit use, which suggests alternative causes.

■ **Maintenance of quality.** The majority of twenty-two HEDIS scores that were comparable between 2004 and 2007 were at least maintained, with a few exceptions: poor HbAlc control in both the commercial and Medicare populations, management of antidepressant medications in the commercial population, and osteoporosis management in women with a fracture in the Medicare population.[7]

■ **Organizational assists.** Organizational efforts to shift ambulatory care use could also explain the changes in rates. Copayments increased $2 per visit per year between 2004 and 2007 as part of a stepped program to increase consumer cost sharing in the most prevalent benefit plan. However, previous larger copayment increases were not related to similar decreases in office visit rates.

The initiation of total panel management (TPM) in 2004 might have had a minimal impact on office visit use. In the TPM model of care, primary care teams identify members of their patient panel who need medications, testing, or other evidence-based care and then use multiple strategies to address these needs, such as telephone visits and secure messaging, in addition to office visits. TPM can reduce the need for multiple office visits among people with chronic conditions; however, only 10 percent of KP Hawaii clinics were engaged in TPM during the study period. In addition, office visit use uniformly decreased in clinics without TPM.

An EMR head start. The existence of an earlier electronic medical record (EMR) may also have affected our findings. KP Hawaii had partially phased in another electronic system, Clinical Information System (CIS). At the time of KP HealthConnect implementation, a third of care sites had had full CIS functionality for just over two years; the rest had read-only access.[8] An 87 percent drop in daily pulls of paper charts after KP HealthConnect was implemented indicates that CIS was largely used alongside paper charts. However, the two systems shared some functionality. It is possible that CIS also slightly reduced office visits, which would have attenuated the effects we observed from KP HealthConnect.

Efficiency and productivity. We did not examine changes in the efficiency or productivity of providers immediately around the time of implementation. Temporary decreases in productivity of as much as 15 percent are common at implementation.[9]

EHRs may increase the time it takes to document patient visits.[10] We did not examine the impact of KP HealthConnect on net efficiency. Doing so would have required quantifying costs of increased documentation time and savings in nursing, receptionist, and appointment clerk time from decreased office visit rates. In addition, costs to patients of office visits—such as out-of-pocket expenses and time costs of travel, parking, and missed school or work—are often overlooked when one is calculating net efficiency. An average visit in the community can consume 103 minutes (Exhibit 6). In contrast, e-mail messaging and scheduled telephone visits consume much less time; logic suggests that the efficiency gains offset any increases in documentation time.

Study limitations. Limitations of our study include the fact that the system ar-

EXHIBIT 6
Average Time Spent By Patients For An Ambulatory Care Visit In The Community, 1998–2008

Patient activity	Minutes
Travel to and from ambulatory care[a]	50
Receptionist check-in/out[b]	10
Waiting room wait[c]	15.9
Exam room wait[d]	10.4
Time with provider[e]	16.4

SOURCES: See below.
[a] C.B. Forrest and B. Starfield, "Entry into Primary Care and Continuity: The Effects of Access," *American Journal of Public Health* 88, no. 9 (1998): 1330–1336.
[b] L.A. Backer, "Strategies for Better Patient Flow and Cycle Time," *Family Practice Management* 9, no. 6 (2002): 45–50.
[c] K.M. Leddy, D.O. Kaldenberg, and B.W. Becker, "Timeliness in Ambulatory Care Treatment: An Examination of Patient Satisfaction and Wait Times in Medical Practices and Outpatient Test and Treatment Facilities," *Journal of Ambulatory Care Management* 15, no. 42 (2003): 138–149.
[d] Leddy et al., "Timeliness in Ambulatory Care Treatment."
[e] Kaiser Permanente, internal study, 2008.

chitecture and implementation schedule precluded a randomized controlled trial. We were also unable to compare our findings against utilization rates in other KP regions because they were all in various stages of implementing KP HealthConnect during our study period. However, we note that the rate of ambulatory care visits has been rising since the mid-1990s in the United States as a whole.[11]

Additional limitations include the fact that our data on quality and patient satisfaction were drawn from contemporaneous tools and were not specific to this study. Changes in the HEDIS measure set between 2004 and 2007 restricted our ability to compare quality before and after EHR implementation. The long-term effects of telephone visits and secure patient-physician messaging on efficiency, quality, and patient satisfaction are unknown and require measuring impacts during a longer time period.

Our report falls short of a comprehensive evaluation of the impact of KP HealthConnect, which would require monetizing efficiency shifts. This is challenging in KP's integrated cost structure and beyond the scope of this study. In contrast to fee-for-service systems, Permanente Medical Group physicians receive a fixed salary regardless of the number of services rendered. Permanente Medical Groups provide medical care for members under a mutually exclusive contract with the Kaiser Foundation Health Plan.

■ **Economic impact of EHRs.** Further study may yield important findings about the overall economic impact of implementing a comprehensive EHR in the outpatient setting. It should be noted, however, that the CBO suggests that the adoption of more health IT is generally not sufficient to produce significant cost savings in the absence of incentive structures that reward (or, at a minimum, do not disincent) efficiencies.[12] The U.S. Department of Health and Human Services (HHS) suggests that a comprehensive evaluation would include measures of quality, patient safety, costs of direct care, administrative efficiencies, decreased paperwork, and expanded access.[13]

■ **Consistency with previous KP study.** Our findings are consistent with those of a study KP published in 2005.[14] Decreased office visits and increased scheduled telephone visits indicate that to some degree, telephone visits can substitute for office visits with immediate access to complete, current patient information via an integrated EHR. However, the previous study did not involve the more comprehensive KP HealthConnect system or secure e-mail messaging. KP also documented that secure e-mail messaging can provide an asynchronous, convenient substitute for some office and telephone visits.[15]

The 26.2 percent reduction in office visits indicates greater efficiency of care with an integrated EHR. With complete patient data available, unnecessary and marginally productive office visits are reduced or replaced with telephone visits and secure e-mail messaging supported by easy access to patients' medical records. For example, doctors reported that the EHR enabled them to resolve patients' health issues in the first contact or with fewer contacts.[16] In sum, our study

"Until public and private policies reward care strategies other than face-to-face visits, few providers will adopt them."

strongly suggests that an integrated and comprehensive EHR shifts the pattern of ambulatory care toward more-efficient contacts for patients and providers while at least maintaining quality of care and patient satisfaction.

■ Importance of aligned financial incentives. Importantly, our results were obtained in an integrated delivery system with an economic model that aligns financial incentives with providing effective and efficient care, regardless of how that care is delivered. As the CBO notes, "How well health IT lives up to its potential depends in part on how effectively financial incentives can be realigned to encourage the optimal use of the technology's capabilities."[17]

A specific example from KP Hawaii illustrates the potential that health IT holds for transforming care when incentives are properly aligned. The Hawaii regional team of nephrologists took advantage of the ready availability of comprehensive clinical information on all patients to risk-stratify the entire regional population with chronic kidney disease. Using evidence-based guidelines to electronically review the health records of thousands of members, they instituted proactive, risk-driven, electronic consultations instead of relying only on primary care providers to refer patients for specialty care. These consultations sometimes recommended traditional specialty visits but often provided care recommendations remotely, using electronic communication. Nephrologists used KP HealthConnect's internal messaging feature to provide KP primary care physicians with clinical management advice tailored to specific patients. Over three years, major improvements occurred in key indicators of quality of care for chronic kidney disease.[18]

■ Policy implications. Until public and private policies reward care strategies other than face-to-face visits, few providers will adopt them. Only in 2008 did the Centers for Medicare and Medicaid Services (CMS) add codes for telephone contacts that are intended to supplant office visits and for online management. Medicare, however, listed both services as noncovered for 2008, leaving it to the discretion of individual insurers whether to pay for these services.[19] Private insurers reimburse providers for online visits on a very limited basis.[20]

■ Factoring in consumers' preferences. Aligning nonfinancial incentives for using EHRs to improve the efficiency of care is also necessary. For instance, the National Committee for Quality Assurance (NCQA) relies on office visits as the predominant indicator of quality-related activity.[21] However, consumer choice is a key component of value-driven care.[22] Increasing evidence identifies patients' clear preferences for and satisfaction with e-mail messaging with their doctors.[23]

The KP experience is similar; among users of KP HealthConnect in KP Northwest, 85 percent rated their satisfaction as 8 or 9 on a nine-point scale.[24] In a separate survey, 85 percent of users indicated that the ability to communicate electronically with their physicians enabled them to better manage their health.[25]

If face-to-face visits remain the gold standard for quality, care standards will not reflect the preference of consumers for alternative, more convenient modes of care when they are appropriate or reinforce more efficient care delivery options.

KAISER PERMANENTE'S WORK IN THIS AREA is still in progress. We will continue to evaluate the impacts of KP HealthConnect on care and administrative efficiencies, quality, safety, and access over the long term. This report is interim, insofar as KP continues to innovate and improve workflows to create a new value equation for patients and purchasers. However, it provides a view into the transformation of ambulatory care that emerges and is increasingly possible when technology and incentives align with patients' preferences.

The authors thank the many physicians, operations leaders, and analysts in the Kaiser Permanente Hawaii region for their contributions. In particular, they thank Yvonne Zhou, Amy Watts, Cynthia Okamura, Fred Shaw, Rod Pederson, Brian Lee, Ravi Poorsina, and Samantha Quattrone for their support and insights; Arnold Matsunobu, Jan Head, and Mike Chaffin for their sponsorship early in the project; and Jenni Green for advice and help in writing this paper.

NOTES

1. See, for example, R. Kaushal, K.G. Shojania, and D.W. Bates, "Effects of Computerized Physician Order Entry and Clinical Decision Support Systems on Medication Safety: A Systematic Review," *Archives of Internal Medicine* 163, no. 12 (2003): 1409–1416; L.C. Burton et al, "Using Electronic Health Records to Help Coordinate Care," *Milbank Quarterly* 82, no. 3 (2004): 457–481; J. Hippisley-Cox et al., "The Electronic Patient Record in Primary Care—Regression or Progression? A Cross Sectional Study," *BMJ* 326, no. 7404 (2003): 1439–1443; J. Butler et al., "Improved Compliance with Quality Measures at Hospital Discharge with a Computerized Physician Order Entry System," *American Heart Journal* 151, no. 3 (2006): 643–653; and B. Chaudhry et al., "Systematic Review: Impact of Health Information Technology on Quality, Efficiency, and Costs of Medical Care," *Annals of Internal Medicine* 144, no. 10 (2006): 742–752.
2. Peter R. Orszag, Congressional Budget Office, "Evidence on the Costs and Benefits of Health Information Technology," Testimony before the House on Ways and Means Subcommittee on Health, 24 July 2008, http://www.cbo.gov/ftpdocs/95xx/doc9572/07-24-HealthIT.pdf (accessed 22 December 2008).
3. "Total office visits" include care from medical and osteopathic doctors, resident physicians, nurse practitioners, physician assistants, registered nurses, optometrists, social workers, and rehabilitative therapists. "Primary care visits" include clinic-based care from internal medicine, family practice, and pediatric physicians. "Specialty care visits" include clinic-based care by other specialty and subspecialty physicians. "Scheduled telephone visits" include prearranged phone calls between providers and patients. "External referrals" include only non–Kaiser Permanente ambulatory consultations. "Emergency department visits" include visits to KP and non-KP emergency departments (EDs). "Urgent care visits" include care at KP urgent care centers; these are not included in total office visits.
4. National Committee for Quality Assurance, "HEDIS and Quality Measurement," 2008, http://www.ncqa.org/tabid/59/Default.aspx (accessed 21 November 2008).
5. Agency for Healthcare Research and Quality, "CAHPS: Surveys and Tools to Advance Patient-Centered Care," 2008, http://www.cahps.ahrq.gov/default.asp (accessed 21 November 2008).
6. Kaiser Permanente, internal study, 2007.
7. Hawaii regional clinicians conducted a close review of antidepressant follow-up and noted discrepancies between care that occurred and care that was "counted" under HEDIS criteria. For instance, if follow-up on the use of antidepressant medications occurred during a visit but depression was not the primary diagnosis, it did not count toward the HEDIS measure. Scheduled telephone visits that were inaccurately

coded as "telephone encounters" also did not count toward the measure.

8. J.T. Scott et al., "Kaiser Permanente's Experience of Implementing an Electronic Medical Record: A Qualitative Study," *BMJ* 331, no. 7528 (2005): 1313–1316.
9. D. Gans et al., "Medical Groups' Adoption of Electronic Health Records and Information Systems," *Health Affairs* 24, no. 5 (2005): 1323–1333.
10. L. Poissant et al., "The Impact of Electronic Health Records on Time Efficiency of Physicians and Nurses: A Systematic Review," *Journal of the American Medical Informatics Association* 12, no. 5 (2005): 505–516.
11. E. Hing, D.K. Cherry, and D.A. Woodwell, "National Ambulatory Medical Care Survey: 2004 Summary," Advance Data from Vital and Health Statistics no. 374, 23 June 2006, http://www.cdc.gov/nchs/data/ad/ad374.pdf (accessed 22 December 2008); and D.K. Cherry, D.A. Woodwell, and E.A. Rechtsteiner, "National Ambulatory Medical Care Survey: 2005 Summary," Advance Data from Vital and Health Statistics no. 387, 29 June 2007, http://www.cdc.gov/nchs/data/ad/ad387.pdf (accessed 22 December 2008).
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14. T. Garrido et al., "Effect of Electronic Health Records in Ambulatory Care: Retrospective, Serial, Cross Sectional Study," *BMJ* 330, no. 7491 (2005): 581.
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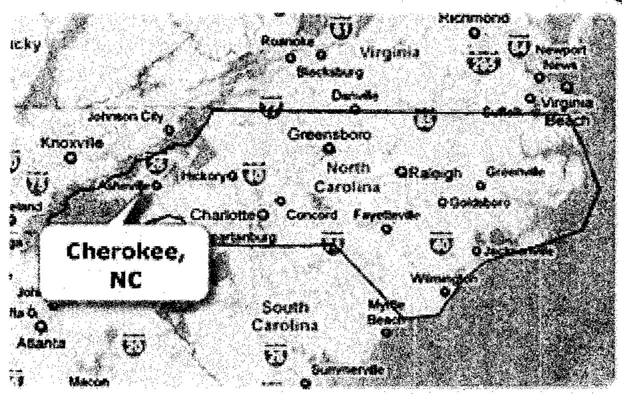
16. Garrido et al., "Effect of Electronic Health Records."
17. Orszag, "Costs and Benefits of Health Information Technology," 7.
18. B. Lee and K. Forbes, "The Role of Specialists in Managing the Health of Populations with Chronic Disease: The Example of Chronic Kidney Disease" (Unpublished manuscript, Kaiser Permanente, 2008).
19. B. Whitman, "2008 CPT Codes Clarify Billing for Phone and Electronic E/M," 2008, http://www.acpinternist.org/archives/2008/01/billing.htm (accessed 21 November 2008).
20. M. Merrill, "Insurers Reimburse IADMD Members for Online Visits," *Healthcare IT News*, 29 February 2008, http://www.healthcareitnews.com/story.cms?id=8780 (accessed 21 November 2008).
21. National Committee for Quality Assurance, *The State of Health Care Quality 2007* (Washington: NCQA, 2007).
22. DHHS, "Value-Driven Health Care Home," http://www.hhs.gov/valuedriven/index.html (accessed 21 November 2008).
23. A. Hassol et al., "Patient Experiences and Attitudes about Access to a Patient Electronic Health Care Record and Linked Web Messaging," *Journal of the American Medical Informatics Association* 11, no. 6 (2004): 505–513; and K.D. Kleiner et al., "Parent and Physician Attitudes regarding Electronic Communication in Pediatric Practices," *Pediatrics* 109, no. 5 (2002): 740–744.
24. C.A. Serrato, S. Retecki, and D. Schmidt, "MyChart—A New Mode of Care Delivery: 2005 Personal Health Link Research Report," *Permanente Journal* 11, no. 2 (2007): 14–20.
25. Kaiser Permanente, internal study, 2006.

Cherokee Indian Hospital

"It's not just the technology, but what you do with the data."

Michael Toedt, M.D.,
Clinical Director,
Cherokee Indian Hospital



There are more than 14,000 members of the Eastern Band of Cherokee Indians, most of whom live across a five-county area in the mountains of western North Carolina. Through partnership with the Indian Health Service (IHS), the Tribe has led the way in applying information technology to improve health outcomes. In Cherokee, N.C., the Cherokee Indian Hospital (CIH) is the primary medical home and public health provider to its Cherokee Indian residents. The hospital and satellite clinics serve an important role in the community as the outpatient department logs an average of 22,000 primary care visits per year, and the emergency department sees an additional 20,000 visits each year. The hospital itself is small, with just 20 inpatient beds, 10 emergency department rooms, and 22 outpatient clinic exam rooms. Despite its comparatively small scale relative to larger hospital networks, CIH has nevertheless made the commitment to becoming a 21st century health center.

The hospital was an early adopter of health information technology (health IT), implementing the IHS Resource Patient Management System (RPMS). CIH was the first IHS facility to implement the RPMS system in 1986. Nineteen years later, a full EHR system with decision support was implemented to increase the continuity of care and interface with the nearly 150,000 e-prescriptions per year. In 2002, CIH decided to make their hospital the most cutting-edge it could be and adopt the latest comprehensive RPMS -- at that time still in early testing phases -- and, by 2005, that dream became a reality.

There were multiple reasons influencing CIH's updated implementation of the RPMS. It was an obvious choice because the updated implementation meant continuity of data from their existing patient information database going back through the 1980s, but accessed by modern technological updates. The hospital found that the system would support numerous functions, including patient lookup and management of personalized patient lists, and computerized physician order entry for lab interfaces to name a few. RPMS is now used in the ambulatory clinic and satellite clinics by all disciplines and clinical staff levels, including:

- Doctors
- Nurses
- Social workers
- Dieticians
- Physical Therapists
- Pharmacists
- Dentists

As with any significant office change, there were considerable organizational cultural adjustments needed to successfully implement the new EHR. Emergency room doctors had concerns that the new system would slow them down as they documented patient encounters. Hearing the provider resistance, the CIH emphasized that all physicians were responsible for producing better patient outcomes, regardless of whether they used the EHR system or not. As a result of that internal messaging, and the positive results from the use of the updated RPMS system, physician concerns decreased noticeably as those not actively using the system saw their peers starting to achieve better clinical outcomes. Physicians initially unfamiliar with the updated system became supporters once they realized that health IT was enabling the hospital to improve health care quality for its Cherokee population.

However, the EHR implementation also highlighted some gaps in some of the care processes at CIH. To address the inefficiencies in their operations management and clinicians completed process mapping for activities such as patient visits, billing, pharmacy, labs, inpatient nursing, and supply chain. The inefficient processes were then re-engineered to add in the recommendations from the process mapping in order to increase the effective use of the RPMS. A key expectation of updated EHR implementation was the improvement of patient care services as measured using a standardized electronic tool called the Clinical Reporting System (CRS). The tool is now able to analyze performance on over 300 clinical measures, which are collected by the performance management team and reported quarterly. Among the reported measures:

- Domestic violence screening showed a dramatic increase from 1% to 80%
- Tobacco screening nearly doubled from 43% to 80%
- Alcohol screening increased from 4%to 82% in women of childbearing age

Other outcome measures such as desired levels of blood pressure and LDL-cholesterol – two key bellwethers of cardiovascular disease – also improved shortly after implementation. The system continued to report sustained improvements even after increases in patient population and hospital staff turnover. However prior to the system's implementation, CIH's clinical staff could not have predicted the increased openness of physician to patient communications that their new EHR system would afford them. The system generates a patient wellness handout and a diabetes care summary that encourages conversation and reminds both providers and patients of standards of care. In many cases, the clinicians found improved screening was itself therapeutic as patients became more aware of their own conditions. Patient awareness opened up the exam room for qualitative conversations such that it was acceptable, even expected, that such conditions be talked about regularly. The increased access to comprehensive patient data also required CIH to address data security issues. The job of data security fell to the Medical Record Administrator (MRA), who was charged with safeguarding the information in medical records against use by unauthorized persons, loss, defacement, or tampering. The duties of the MRA mandated a hospital policy for access to medical records by staff. After implementing the security policy and maintaining tight security standards, CIH found that the security of its RPMS was considerably better than the previous paper chart security methods. The process of overhauling the legacy system created several learning opportunities for CIH. It became clear that an implementation team was important to obtaining staff buy-in for system use. The CIH team consisted of both "back" and "front" office personnel, including clinicians. Recognizing the staff would need support after the new EHR went "live," the group advised hospital management on issues as they arose until all departments were successfully acclimated to the new system. CIH also recognized it would have to define, document, and conduct drills on backup system operations and processes in the event of a system outage or power loss. The newly documented processes would be included in the hospital's continuity of operations plan. Finally, CIH makes maximum use of templates for documenting clinical information, eliminating free form text entry where possible, thereby making patients visits more efficient. CIH has useful recommendations for other hospitals embarking on an EHR implementation:

- An implementation team is very important, and it should have cross-functional representation (including medicine, pharmacy, nursing, lab, medical records, and IT).
- Train a "super user" or two in every department who can subsequently train other users in the hospital. This helps make health IT a shared responsibility across the care continuum and eventually leads the way to more efficient and high quality health care delivery.

- Implement a system of information feedback on key clinical indicators. Use your clinical leaders to validate and deliver this information, and to motivate the providers. While it is equally important to track financial and service indicators, it will be the improvements in clinical indicators that will get your providers on-board.

Source: Office of the National Coordinator for Health Information Technology, U.S. Department of Health and Human Services

http://healthit.hhs.gov/portal/server.pt?open=512&mode=2&objID=1958&PageID=20411

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Perspective

Finding My Way to Electronic Health Records

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Article

The recent oil spill off the Gulf Coast may prove to be one of the great environmental challenges of our lifetime. It is yet another devastating blow to the Gulf region, a place I call home. My heart goes out to the people there who are concerned about how this latest disaster will affect their livelihood and their health. Though the full effects of the spill remain to be seen, already the health needs of Gulf Coast inhabitants are increasing during this time of crisis. Physicians in the area will need to adapt and find innovative ways to efficiently deliver health care for an already underserved population. I recall my experiences as a physician during the crises of Hurricanes Georges and Katrina and try to remember how I adapted.

The day after Katrina hit, I drove through Bayou La Batre, a small fishing village on the Gulf Coast where I practiced medicine for 23 years. The damage didn't look so bad when I pulled up to my clinic. However, when I opened the door, I nearly fell sick from the smell of dead fish and crabs. Furniture had been tossed around the office every which way. All the patient information — all the paper records — were ruined. I remember thinking that I had tried to prepare for this kind of crisis and recalling that I had strongly considered moving to electronic health records (EHRs). But money was tight, as it was for many small practices throughout the country, and it eventually came down to a choice: I could either install an EHR system or pay the electricity bill. Searching for a source of courage, I recalled the reasons why I had chosen to become a family physician.

Like many physicians just out of school, I believed strongly in primary care — my mother, father, and brother had all died of preventable diseases. As a National Health Service Corps scholar, I now had the privilege of making a difference in a small community.

Bayou La Batre was my assignment. I was familiar with the town, since I had grown up in nearby Daphne, where my family has been since the early 1800s — the Seafood Capital of Alabama, a shrimping town, where people made their living on the water. But the seafood industry had been hurting, which meant that there was little money for health insurance or out-of-pocket copayments, and more important, that there weren't enough primary care physicians.

Many of my patients spent most of their time on the boats, going out for 2 months at a time. Skipping from coast to coast was part of their job. I remember one patient who had been out for nearly 3 weeks and had used superglue to treat a gash on his hand. My patients had to improvise, and they had few medical options for managing their illnesses, whether acute or chronic. I felt I had arrived in the right place at the right time.

Well, perhaps it wasn't exactly the right time. In 1998, Hurricane Georges made landfall in the Gulf Coast, causing over $100 million in damage to Alabama alone. My clinic was destroyed. Without a building in which to treat patients, my nurse Nell Bosarge and I spent the next 2 years driving my pickup truck to their homes. Eventually, I mustered the resources to rebuild the Bayou La Batre Rural Health Clinic — on higher ground this time, and on 4-ft stilts. Meanwhile, we managed to save the drenched paper records of our patients by carefully drying them in the hot Alabama sun.

In 2005, Hurricane Katrina came, again threatening to destroy the Bayou La Batre Rural Health Clinic. We had 48 hours to evacuate the area and, given the new secure location of the building, saw no reason to pack away all the paper medical records.

When I returned to the Bayou, the building had been destroyed by the water. Nell and I knew we had to get everything out of there, or else it would mildew. We spent just as much time clearing out the medical records — again placing them in the sun in 90-degree weather to dry them, carefully turning them over — as we did trying to salvage the structure of the place. This time, I could not make house calls to my patients' homes, because the vast majority of their homes had been destroyed, too. Our staff set up a makeshift clinic in the auditorium of the local shelter, while volunteers and donations helped us prepare for a January 2 reopening.

Tragedy befell the Bayou Clinic once again, when, in the early morning hours of New Year's Day, just before our clinic was to reopen, a fire broke out and the clinic burned to the ground. This time, the precious patient records — the ones that Nell, the staff, and I had spent hours drying and recovering on two separate occasions — were completely destroyed. We were forced to rely on memory and intuition in treating our patients. Any information on allergies, coexisting conditions, and specific family history was now left to recollection.

Having lost the Bayou Clinic three times, I knew we had to have a better way of practicing. I needed to find a way to deliver high-quality health care to people who didn't have a lot of money. From the experiences with the hurricanes and the fire, I knew we had to be able to evacuate the clinic quickly, while still safeguarding the vital patient information. Whereas I had previously decided against installing an EHR system because I couldn't afford one, I now realized I couldn't afford *not* to have one.

Our trials did not go unnoticed. Wonderful people from all over volunteered their time and money to help us rebuild. A generous donation from a private foundation supported our efforts through the Katrina Phoenix program, helping us rebuild our clinic with computer hardware, in coordination with a generous EHR vendor and with the help of good-hearted student volunteers from Bentley College in Waltham, Massachusetts. They also provided us with support, teaching us how to use the system and helping to implement it in our practice. Needless to say, Nell and I were relieved when we turned on the switch and became a paperless office.

Though it is challenging to persuade some doctors and nurses to convert from paper records, "buy-in" was not an issue at the Bayou Clinic, since Nell and the rest of the staff were adamant about never having to "bake charts in the sun" again. The new system we implemented allowed us to easily track and document our patients' histories; with a click of a button, we could send a prescription or remind patients of upcoming mammograms, thus improving the quality of care. Practicing medicine became easier for the clinicians and better for the patients.

With the availability of new incentive payments made possible by the Health Information Technology for Economic and Clinical Health Act (HITECH), and assistance for the transition to electronic health records available from regional extension centers, small practices like mine now have the kind of support that I had — and fewer reasons to delay a decision that should have been obvious long ago.

Until the day we turned on our EHR system, I was still using pens with waterproof ink. It is a very good thing — for both me and our patients — that my fellow physicians and I don't need to use those pens anymore.

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Disclosure forms provided by the author are available with the full text of this article at NEJM.org.

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